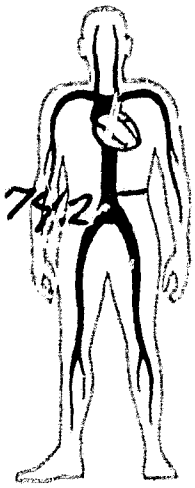

TECHNOLOGY INCORPORATED
LIFE SCIENCES DIVISION

SPECIAL REPORT

OPERATIONS AND MAINTENANCE MANUAL

FOR THE

LINEAR ACCELERATOR (SLED)

Prepared for the NASA Johnson Space Center
Neuroscience Laboratory

February 10, 1981

CONTRACT NAS9-14880

National Aeronautics and Space Administration
Lyndon B. Johnson Space Center
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Approval Sheet

for

Linear Accelerator

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TABLE OF CONTENTS

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1.0 SCOPE

The Linear Accelerator is a sliding chair which is pulled along a stationary platform in a horizontal axis. The driving force is a motor controlled by a velocity loop amplifier, and the mechanical link to the chair is a steel cable. The chair is moved in forward and reverse directions as indicated by the direction of motor rotation.

The purpose of this documentation manual is to provide a description of the system operation with an accent on the electronic control and monitoring functions. In support of this effort, line-by-line schematics and wire lists are included in this documentation package.

2.0 SUPPORTING DOCUMENTATION

The Linear Accelerator is comprised of products from various manufacturers. A list of these manufacturers and their associated user manuals is as follows:

Digital Equipment Corporation

- Microcomputer Processor Handbook
- Microcomputer Interfaces Handbook

Data Systems Design, Inc.

- DSD-210 Diskette Memory System

MDB Systems Incorporated

- MLSI-BPA84 Backplane/Card Guide Assembly
- MLSI-BA11-100 11/03 Enclosure
- MLSI-250-T-5/12S Power Supplies
- MLSI-DLV11 Asynchronous Serial Line Interface

MLSI-KW11P Programmable Real Time Clock

MLSI-SMU System Monitoring Unit

MLSI-DRV11C Parallel Line Interface Module

ADAC Corporation

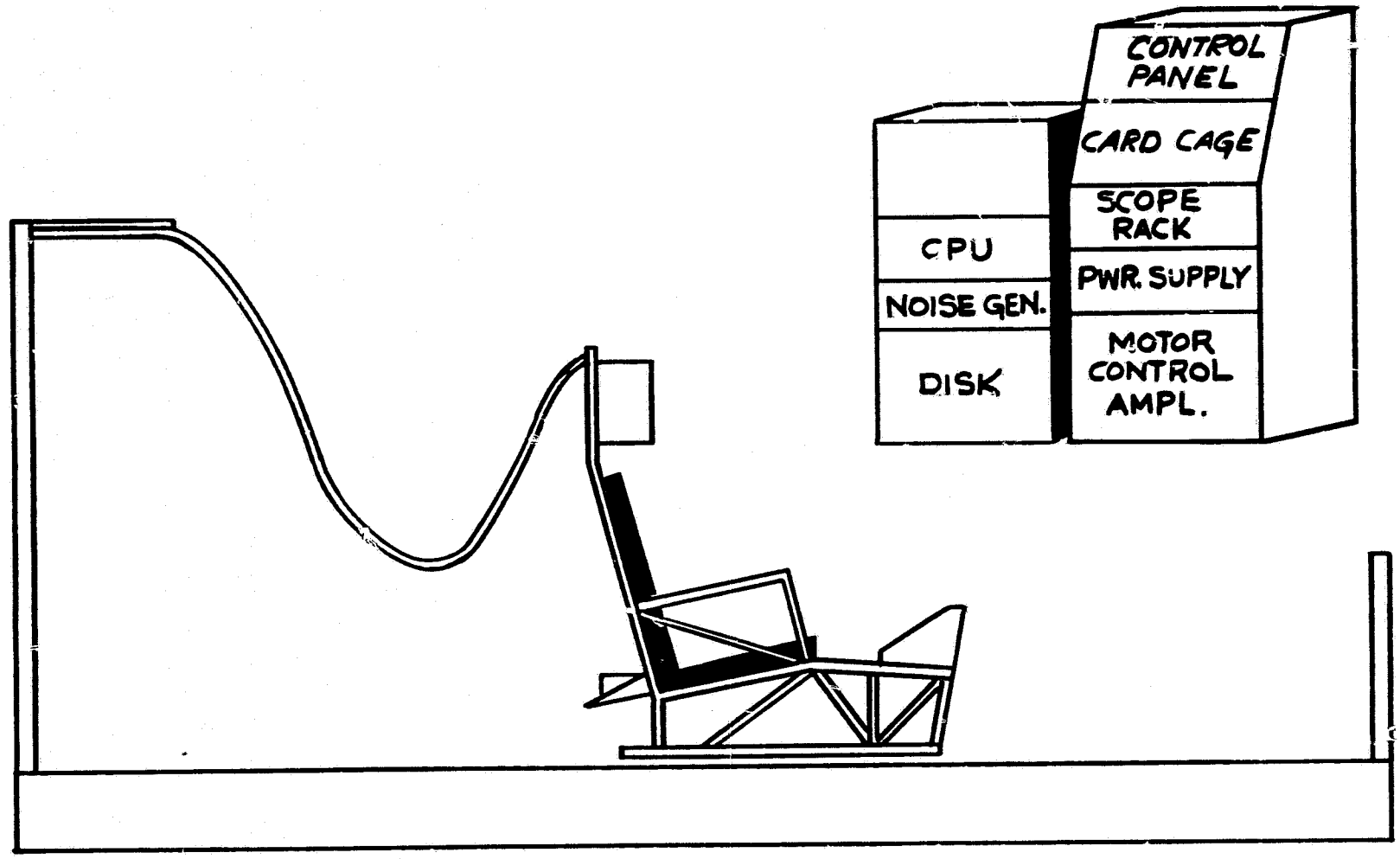
Model 1030 Data Acquisition and Control System

Inland Motor Division, Kollmorgen Corporation

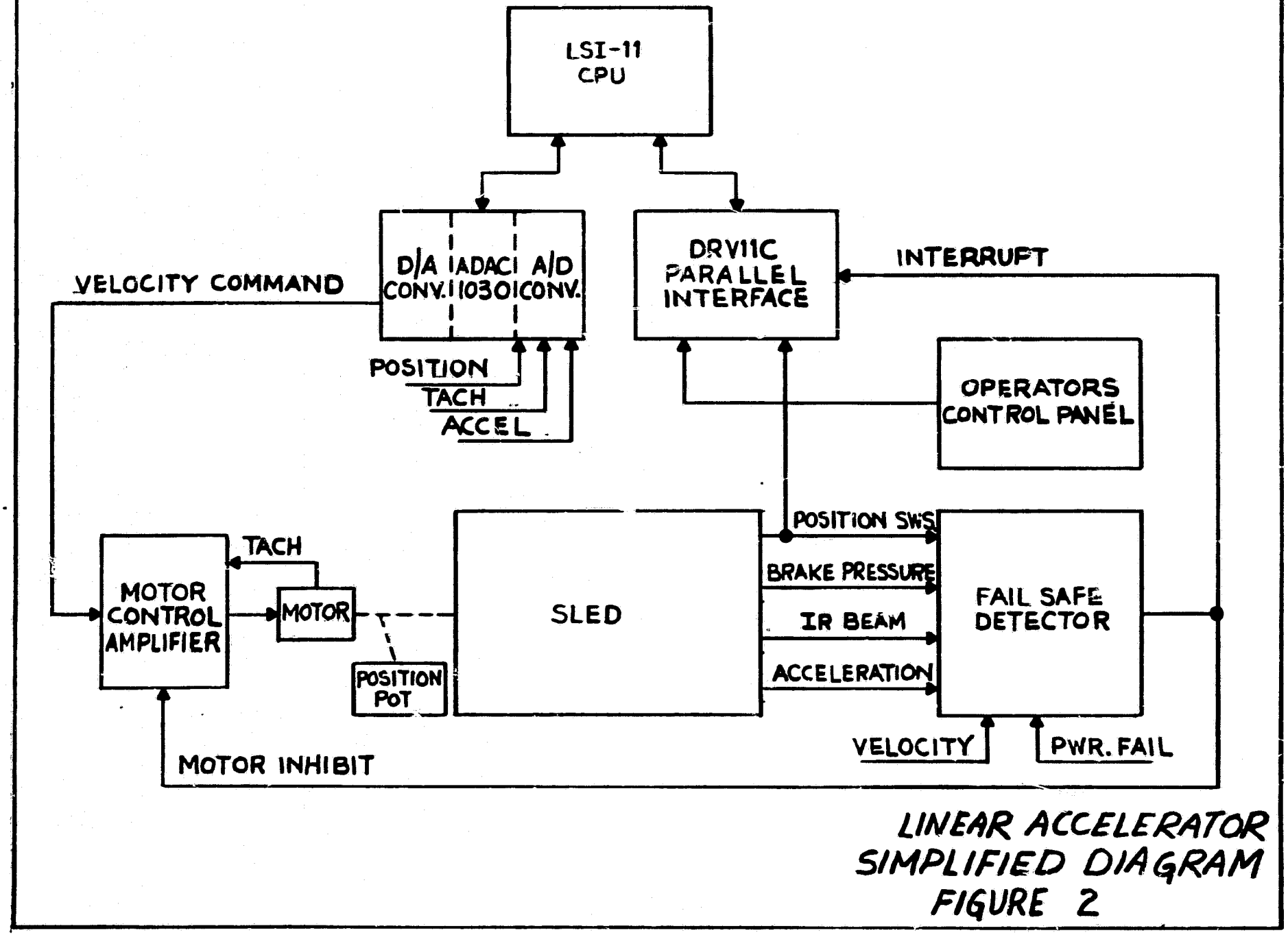
SM-10040 PWM Switching Amplifier

Automatic Timing & Controls Co.

7214 Series Retroreflective Modulated LED Scanner-Controller



LINEAR ACCELERATOR
PICTORAL VIEW
FIGURE 1



LINEAR ACCELERATOR
SIMPLIFIED DIAGRAM
FIGURE 2

3.0 OPERATIONAL DESCRIPTION

The electronics of the Linear Accelerator consist of three major subsystems: the processor, motor control, and the monitoring and control of electronics. Each subsystem is basically independent of the other in the sense that there is no closed-loop (Hardware) feedback control, and each is equipped with its own power supplies. See Simplified Diagram, Electronics Subsystems, Figure 3.

3.1.0 PROCESSOR

The processor serves the function of generating the velocity signal for the motor control amplifier, and scans the monitor/control electronics for coordination of software with actual operation. The velocity signal is generated by a digital-to-analog converter under program control. Certain parameters such as acceleration, position, tachometer, sled position switches, and operator command switches are monitored by the software program for control and calibration of the velocity signal.

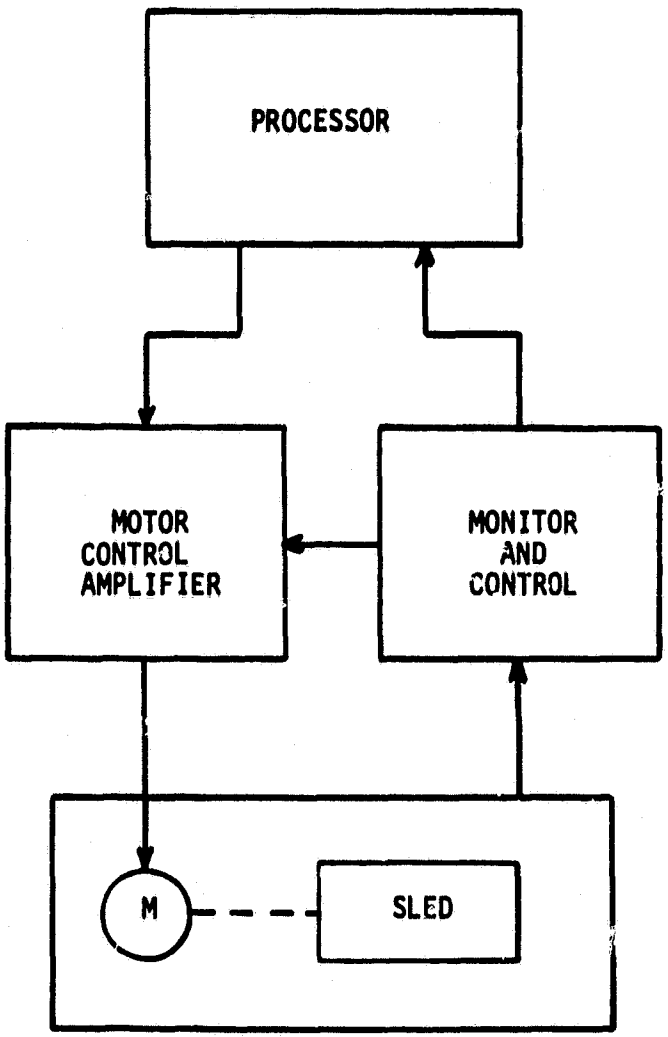
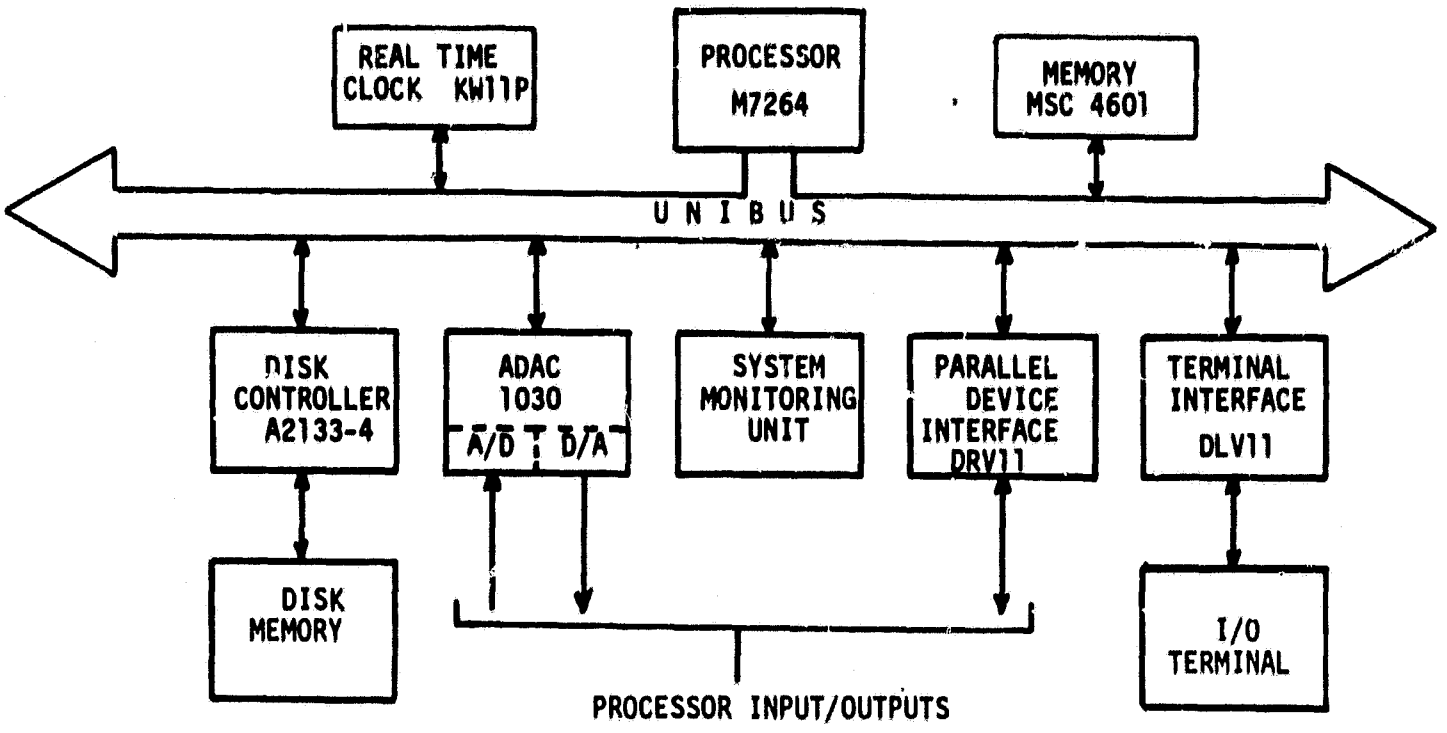


FIGURE 3
SIMPLIFIED DIAGRAM, ELECTRONICS SUBSYSTEMS



SIMPLIFIED DIAGRAM, PROCESSOR CONFIGURATION

FIGURE 4

CPU M7264	
DLV11	MEMORY MSC4601
DISK CONT. A2133-4	DRV11
ADAC 1030	
KW11P	
SMU	

FRONT VIEW

PROCESSOR MODULE LAYOUT

FIGURE 5

The processor is an LSI-11 microcomputer manufactured by Digital Equipment Corporation. It is a 16 bit per word processor and emulates the powerful PDP-11 instruction set. Simplified diagrams of the modular configuration are included in this section, (See Simplified Diagram, Processor Configuration, Figures 4 and 5. For a detailed description of the processor and its modules, the reader should refer to the manufacturer's manual.

The processor I/O signals are itemized as follows with their corresponding interface part and functional description:

3.1.1 PROCESSOR INPUT SIGNALS

NAME	INTERFACE	FUNCTION/SOURCE
EMG	A/D Channel #0	EMG Amplifier output. Physiological response of the test subject.
Position	A/D Channel #1	From the position potentiometer connected to the sled drive motor shaft. A linear voltage representation of sled position: 0 to +7.3V = Forward position from center. 0 to -7.3V = Aft position from center. 0V = Center position.
Tachometer	A/D Channel #2	Output of the tachometer which is an integral component of the sled drive motor.

3.1.1 PROCESSOR INPUT SIGNALS, Continued

Acceleration	A/D Channel #3	Output of the accelerometer amplifier. Scale = .5g per volt
Forward Position Sw.	DRV11	From a normally open microswitch located 52 inches forward from the CENTER position switch. Mechanically activated (closed) by the sled platform. LOGIC 0 = opened LOGIC 1 = closed
Center Position Sw.	DRV11	From a normally-open microswitch located at the center of the sled mainframe. Mechanically activated (closed) by the sled platform. LOGIC 0 = opened LOGIC 1 = closed
Aft Position Sw.	DRV11	From a normally-open microswitch located 52 inches aft from the CENTER position switch. Mechanically activated (closed) by the sled platform. LOGIC 0 = opened LOGIC 1 = closed

3.1.1 PROCESSOR INPUT SIGNALS, Continued

CPU/Manual Mode Sw.	DRV11	From a toggle switch located on the operator's control panel. Used to select the source of the velocity signal. LOGIC 0 = CPU Mode LOGIC 1 = Manual Mode
Go/Stop Sw.	DRV11	From a toggle switch located on the operator's control panel. Used to enable or disable sled drive motor. LOGIC 0 = Go LOGIC 1 = Stop
Request A	DRV11	From the FAIL SAFE DETECTOR LOGIC. Used as an interrupt input to the processor. Activated with one or more of the following FAIL SAFE conditions: 1) Acceleration greater than .5g 2) IR beam (Perimeter) broken 3) SMU detection of power failure 4) Detector logic clock failure 5) Runaway (velocity signal greater than .6 volt and sled is at either FORWARD or AFT position switch).

6) Low brake pressure.

This input is also activated whenever the GO/STOP switch is in the STOP position and when the CPU/Manual mode switch is in the MANUAL mode.

3.1.2 PROCESSOR OUTPUT SIGNALS

NAME	INTERFACE	FUNCTION/DESTINATION
Velocity	D/A #1	Velocity command to the motor control amplifier. Scale = -5V to +5V A positive voltage moves the sled in a forward direction and a negative polarity moves it in the reverse direction. The speed of the motor is proportional to the amplitude, and the distance of sled travel is a function of the frequency.
Stimulus	D/A #2	Actuating (trigger) signal to the stimulus device (CCIU-8). Used in physiological studies of the test subject only.

3.1.2 PROCESSOR OUTPUT SIGNALS, Continued

CSR0	DRV11	A digital output of the interface control/status register used to select the hardware scaling of the velocity command. Logic 0 = Lo Scale Logic 1 = Hi Scale Scaling is accomplished by attenuating the signal by a factor of 5:1 (Lo Scale) and 2:1 (Hi Scale).
CSR1	DRV11	A digital output of the interface control/status register used to enable or disable the motor drive current when the CPU/Manual switch is in the CPU mode. Logic 0 = Stop Logic 1 = Go
Data Xmitted	DRV11	A logic pulse (500 Nsec) used to clear (reset) the REQUEST A signal. This pulse is generated whenever the interface input buffer is read by the software program.
Initialize	DRV11	A logic pulse asserted by the processor to clear all devices connected to the unibus. Generated with a power-up condition or by a RESET instruction.

3.2 MOTOR CONTROL AMPLIFIER

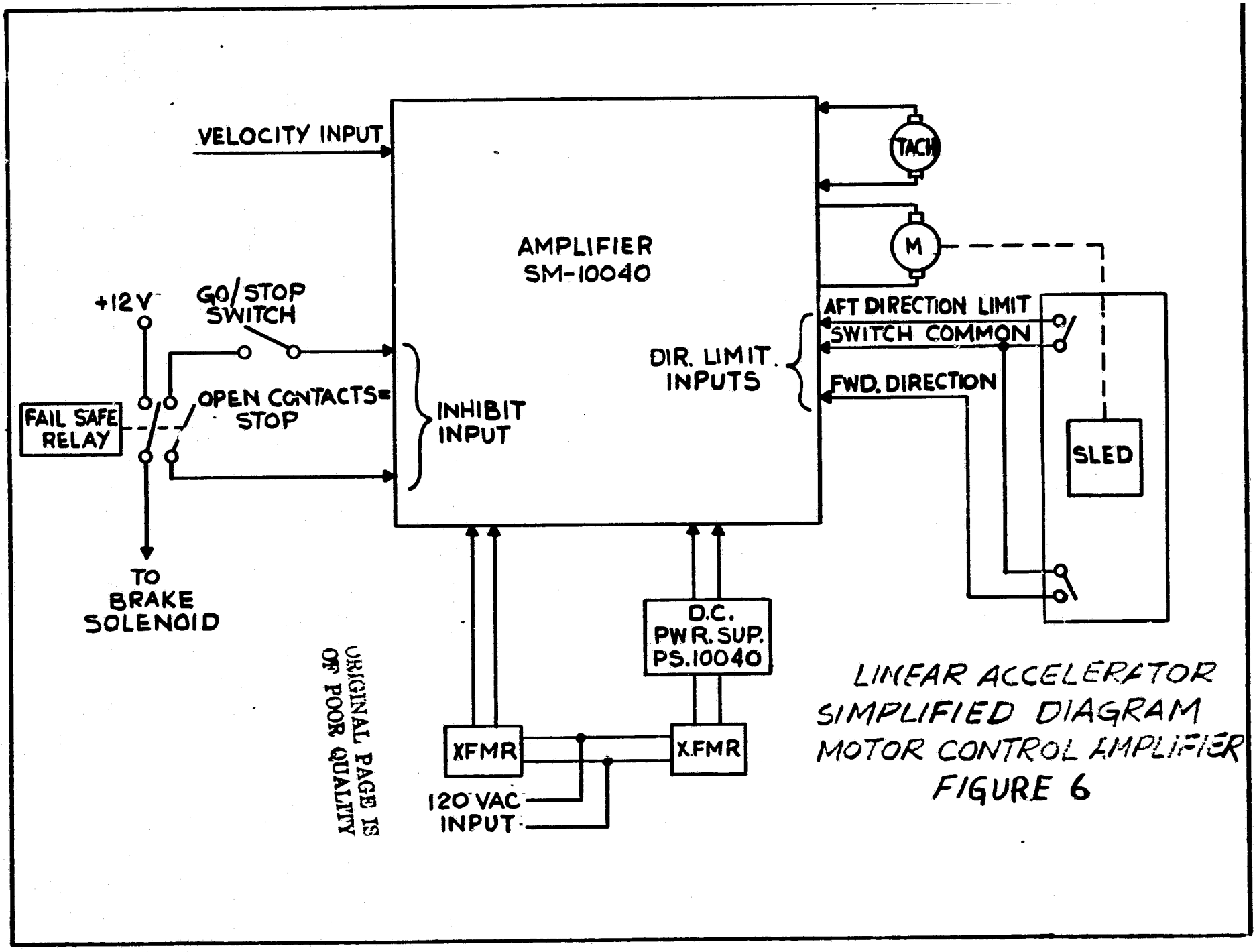
Reference the Simplified Diagram, Figure 6.

The Motor Control Amplifier is a self-contained sub-system within the Linear Accelerator in that it is equipped with its own power supply and requires only a velocity command signal. There is no feedback loop with the system's other devices or sub-systems. For a more complete operational description of the motor controls refer to the Kollmorgen Corporations' Technical Manual for the SM10040 Amplifier.

The amplifier is a velocity loop amplifier which maintains a speed proportional to the command signal. The output of the amplifier is the drive current to the motor. With a given velocity command, the amplifier compares the commanded speed to the actual speed, as recorded by the tachometer, and emits a signal to produce more or less current as necessary to speed up or slow down the motor.

The amplifier is equipped with contact-closure inputs which are used to inhibit and/or limit the operation. The "INHIBIT" input (TB2-13 & 14) of the amplifier prevents the amplifier from outputting drive current to the motor. As shown in the Simplified Diagram, this input is connected to the GO/STOP switch in series with the fail safe relay contacts. When either is "opened", the amplifier is inhibited.

The direction of motor movement is also inhibited by contact-closures. These inputs, forward limit and reverse limit, are connected to normally-open switches located near the forward and aft ends of the sled mainframe. When the sled reacnes a limit switch, the contacts close, and the amplifier will not respond to an additional velocity signal in that corresponding direction, however, a velocity signal in the opposite direction will be acknowledged by the amplifier.



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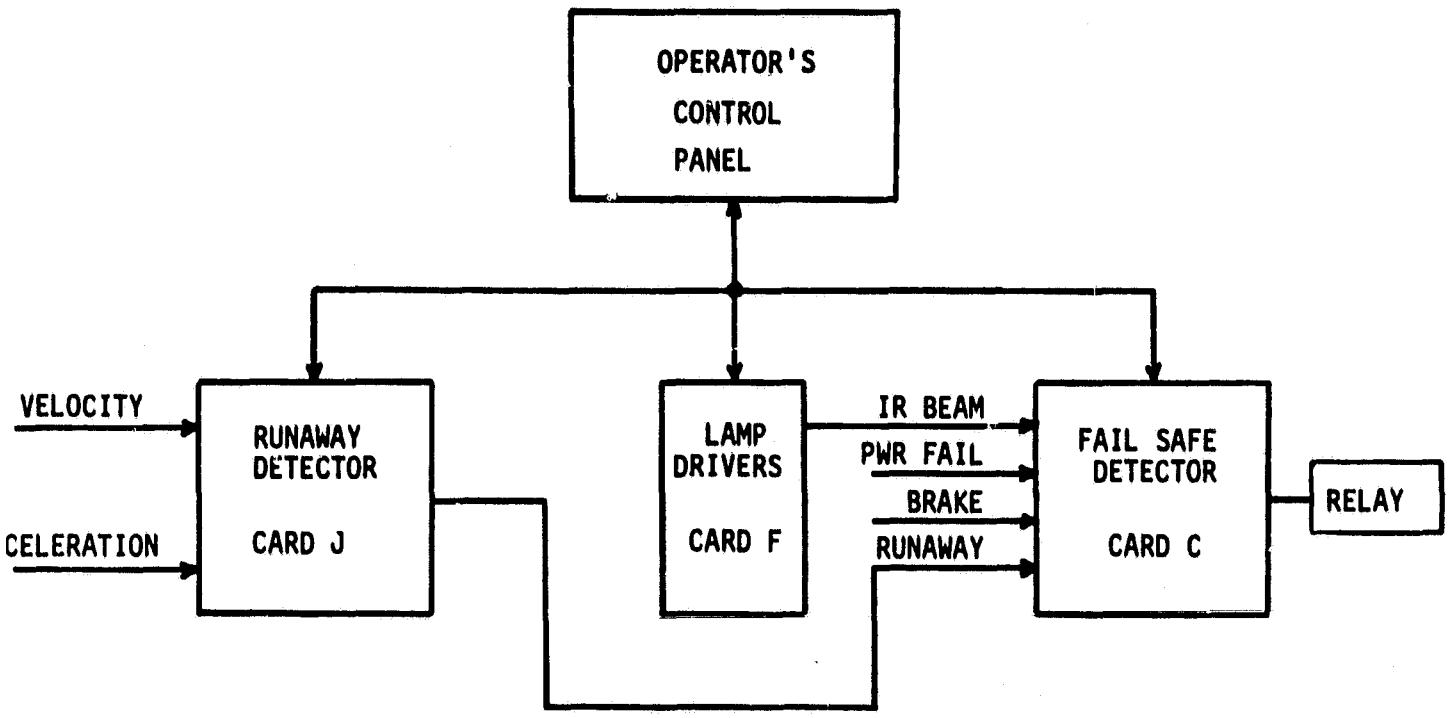
LINEAR ACCELERATOR
SIMPLIFIED DIAGRAM
MOTOR CONTROL AMPLIFIER
FIGURE 6

The amplifier is equipped with other optional inputs that are not incorporated in the Linear Accelerator Application. These optional features are described in the manufacturer's manual.

3.3.0 MONITOR AND CONTROL ELECTRONICS

This subsystem is comprised of the operator's control panel and the Logic Card Rack which houses the FAIL SAFE DETECTOR, RUNAWAY DETECTOR, and LAMP DRIVERS. These logic circuits monitor key parameters and control functions which define the operation of the sled movement and control a relay which (when deactivated) inhibits the sled motor drive current and activates the brake. Reference Figure 7.

3.3.1 The RUNAWAY DETECTOR (Card J) detects a runaway condition by comparing the acceleration voltage to a fixed reference threshold voltage of 1.0 volt. With the accelerometer amplifier selected to a scale .5g per volt, this circuit will shut down the sled movement any time acceleration exceeds .5g. A second condition which constitutes a runaway condition is detected if the velocity exceeds .6 volt (positive or negative) when the sled is physically located at either the FORWARD or AFT position switches. These switches are located 104 inches apart and the normal operating profile should be within this distance. This feature prevents the sled from hitting the mechanical "dead end" of the mainframe with any kind of dangerous force.



SIMPLIFIED DIAGRAM

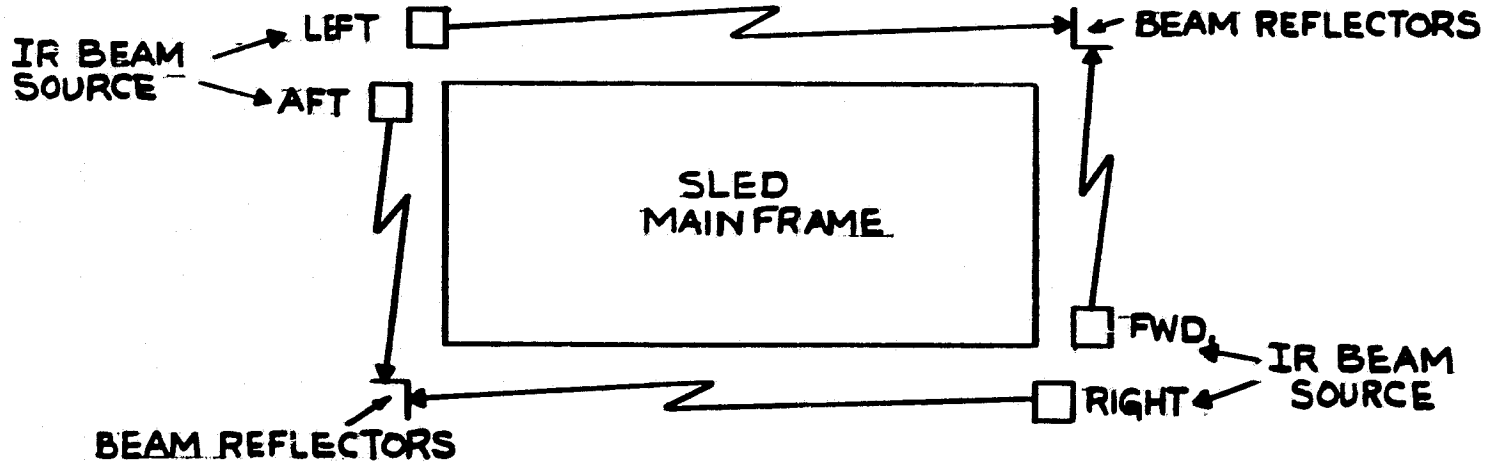
MONITOR & CONTROL ELECTRONICS

FIGURE 7

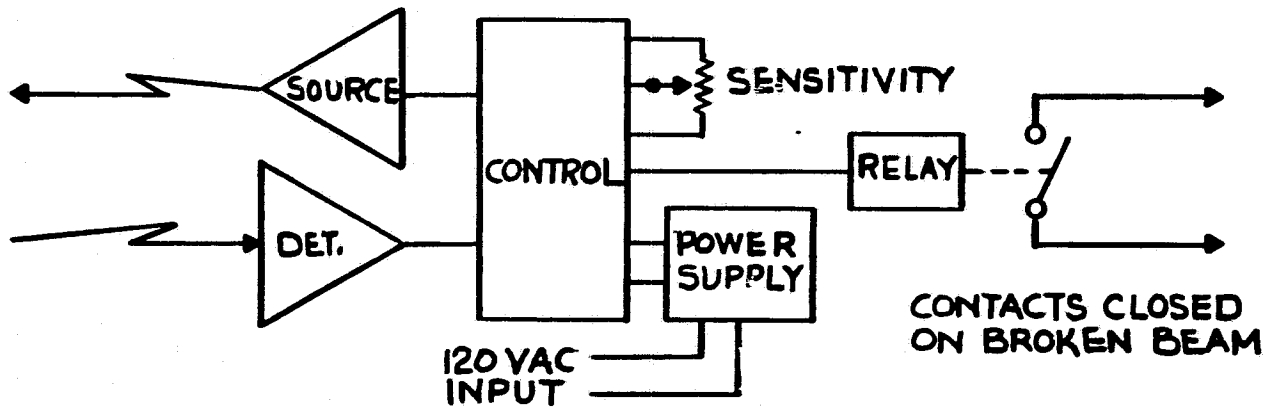
The reference voltages for both velocity and acceleration are provided by a resistive voltage divider located on the card. Several voltage taps are available in .3 volt steps to provide a degree of flexibility if higher, or lower, acceleration profiles are desired in the future.

3.3.2 The FAIL SAFE DETECTOR (Card C) monitors various input signals which denote when a fail safe condition exists and, upon activation, inhibits the sled motor drive current by controlling a relay. These fail safe signals are: (1) RUNAWAY, (2) SMU POWER FAILURE, (3) LOW BRAKE PRESSURE, (4) IR BEAM, and (5) CLOCK FAILURE. Any one or more of these conditions will open the fail safe relay contacts to inhibit motor current and apply the brake. The RUNAWAY signal is described in the foregoing paragraph. The POWER FAIL signal is a contact-closure input from the brake pressure switch which is activated when the pressure drops below approximately 50 pounds. The IR BEAM signal is asserted when the perimeter beam around the sled mainframe is interrupted. The CLOCK FAILURE signal monitors an on-board clock which is used by the detection logic, and is activated by an absence of clock pulses.

3.3.3 The LAMP DRIVERS (Card F) contain switch debouncer logic for the position switches, lamp drivers for the indicator lamps on the control panel, and a control circuit for the RESET function. The reset switch on the control panel is used to clear the FAIL SAFE DETECTOR CARD. Once a FAIL SAFE condition is detected, certain operator procedures must be met in order to clear the detection logic depending upon the



PHYSICAL CONFIGURATION



LINEAR ACCELERATOR
SIMPLIFIED DIAGRAM
INFRARED BEAM CONTROLLER
FIGURE 8

mode of operation (CPU or MANUAL). In the manual mode, the GO/STOP switch must be in the STOP position to allow the RESET function. In the CPU mode, the processor's program must clear the CSR1 signal, and the GO/STOP switch must be in STOP, in order to permit the resetting of alarms. This feature prevents the enabling of motor current with a velocity signal present.

3.4 OPERATOR'S CONTROL PANEL

The operator's control panel is comprised of various switch controls and indicator lamps for man-to-machine interfacing. Each indicator and control is listed below with its functional description.

IR BEAM INDICATORS AFT, FWD, RIGHT, LEFT	Lamps are "on" when the IR Beam is properly aligned with its beam reflector, and "off" when the beam is interrupted.
SLED POSITION INDICATORS	Lamp is "on" when the associated position switch is closed.
CLOCK FAIL INDICATOR	Lamp is "on" when an absence of the clock pulse is detected on Logic Card #C.
SCALE INDICATORS HI, LO	Lamp is "on" to indicate the selected velocity signal scale.

3.4 OPERATOR'S CONTROL PANEL, Continued

CPU/MANUAL SWITCH	Selects the source from which the velocity signal is received. CPU MODE = Velocity signal is generated by the processor (CPU). MANUAL MODE = Velocity signal is generated by the manual position switch.
MANUAL POSITION SWITCH FWD, AFT	Springloaded switch to the OFF position. FWD position supplies a positive voltage (+0.5v) to move the sled in the forward direction. AFT position supplies a negative voltage (-0.5v) to move the sled in the aft direction. Sled movement is sustained for the time period that the switch is held.
GO/STOP SWITCH	GO position enables the movement of the sled if no fail safe conditions are present. STOP position inhibits sled movement.

RESET SWITCH	Used to clear the fail safe detector logic. When the CPU/MAN switch is in the CPU position, the CPU must have CSR1=zero and the GO/STOP switch must be in the STOP position to enable the reset function. In the manual mode, only the GO/STOP switch in STOP position is required to enable the reset function.
LAMP TEST	Turns on all lamp drivers to provide an operator lamp check.
BNC CONNECTORS	Provides monitoring of the velocity, acceleration, tachometer, position pot, stimulus, and EMG signals.

4.0 PROGRAMMING

4.1.0 HARDWARE PROGRAMMING

The Parallel Device Interface (DRV11) and the A/D-D/A module (ADAC 1030) are equipped with user jumper options for flexibility and compatibility with various applications. This section lists the jumpers which are installed (or omitted) for the Linear Accelerator Application.

4.1.1 DRV11C, PARALLEL DEVICE INTERFACE

Register Address Selection

CSR	167770
OUT BUF	167772
IN BUF	167774

Address

Jumper Location	Jumper
1	L-M
2	H-J
3	K-J
4	L-M
1	H-J
2	L-M
3	N-M
5	H-J
5	N-M
4	H-J

Vector Address Selection

Vector = 300 (INTR A)

304 (INTR B)

Vector Address

Jumper Location	Jumper
7	Omit H-J
10	Omit H-J
9	Omit H-J
8	Connect H-J
6	Connect H-J

4.1.2 ADAC 1030, A/D AND D/A CONVERTERS

A/D RANGE (+10 TO -10 volts)

Jumpers:

4-1, 5-3, B-G, E-U

Pseudo - Differential Input

Jumpers:

1-2, D-N

Install .01 ufd capacitor from 3 to 4

D/A RANGE

DAC #1 (+5 to -5 volts)

Jumpers:

B-C, E-F, M-B

DAC #2 (+10 to -10 volts)

Jumpers:

A-B, E-F, M-B

Register address selection

No jumpers required

Status Register	176770
A/D Data Register	176772
DAC 1 Data Register	176760
DAC 2 Data Register	176762

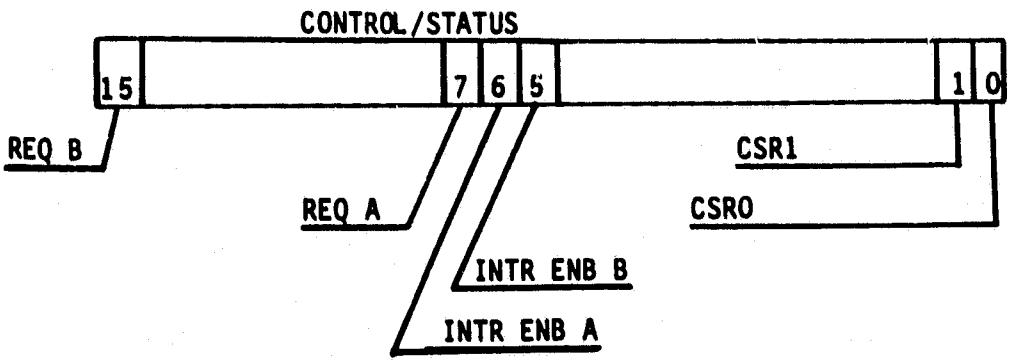
4.2.0 SOFTWARE PROGRAMMING

This section describes the registers and bit-formats of the DRV11C and ADAC 1030 modules as used in the Linear Accelerator Application.

4.2.1 DRV11C, PARALLEL DEVICE INTERFACE

REGISTER	UNIBUS ADDRESS
Control/Status	167770
Output Buffer	167772
Input Buffer	167774

Interrupt A Vector	300
Interrupt B Vector	304



BIT		DESCRIPTION
00	CSR0	READ/WRITE by software used to select velocity scaling. 0 = Lo Scale 1 = Hi Scale
01	CSR1	READ/WRITE by software used to inhibit sled movement. 0 = Stop 1 = Go
05	INTR ENB B	READ/WRITE by software. Not used in the Linear Accelerator Application.
06	INTR ENB A	READ/WRITE by software. Set to allow interrupt to be generated when REQ A BIT 07 is set.
07	REQ A	Set by hardware, read and cleared by software. Set whenever a fail safe condition exists, i.e., IR beam broken, SMU

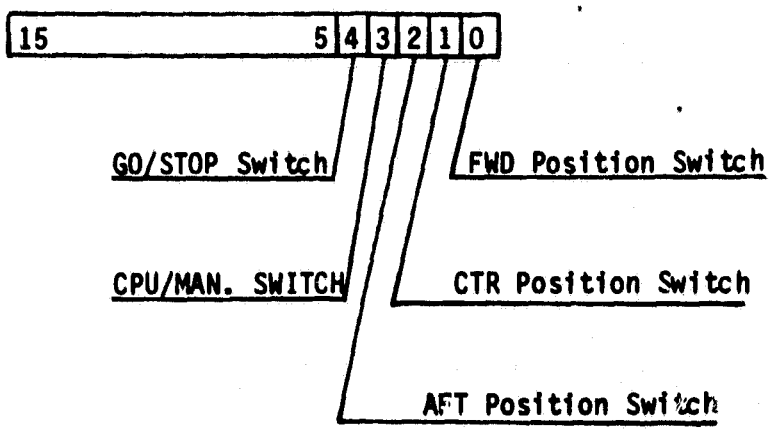
		power fail, brake pressure low, runaway detection, or clock failure. This bit is also set whenever the GO/STOP switch on control panel is in the STOP position, or when CPU/Manual switch is in MANUAL position. Cleared by the assertion of "INITIALIZE" or "DATA XMITTED". DATA XMITTED is generated by the DRV11C Logic whenever the input buffer (167774) is read by the software. If an interrupt is enabled (BIT 06) "DATA XMITTED" should be generated at the end of the interrupt service routine.
15	REQ B	Set by hardware, read by software. Not used in the Linear Accelerator Application. Will always be read as a Logic One by software.

OUTPUT BUFFER

BITS 0 - 15 READ/WRITE register by software.

Not used in the Linear Accelerator Application.

INPUT BUFFER



BIT

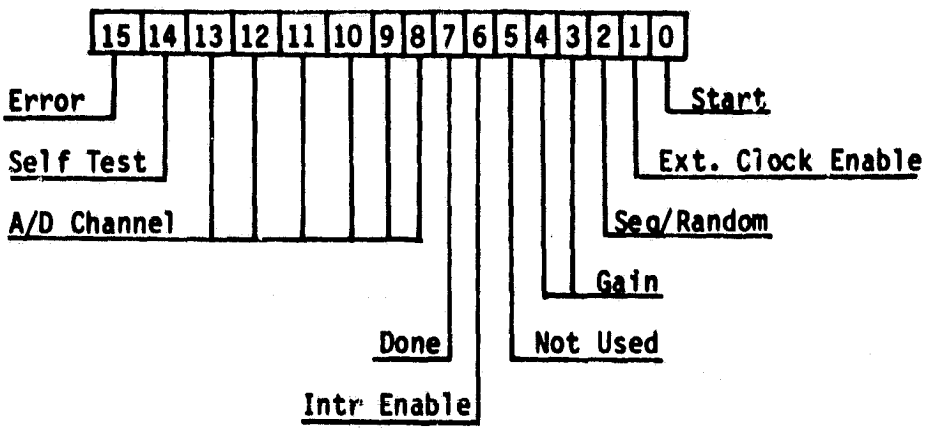
00 FWD Position Sw. Read only bit by software. Set when sled activates the FORWARD position switch.

01	CTR Position Sw.	Read only bit by software. Set when sled activates the CENTER position switch.
02	AFT Position Sw.	Read only bit by software. Set when sled activates the AFT position switch.
03	CPU/MAN Sw.	Read only bit by software. 1 = Manual mode 0 = CPU mode
04	GO/STOP Sw.	Read only bit by software. 1 = STOP 0 = GO
05-15	Not used	Read only bits by software. Always read as logic ones.

4.2.2 ADAC MODEL 1030, A/D AND D/A CONVERTERS

REGISTER	UNIBUS ADDRESS
Status Register	176770
A/D Data Register	176772
DAC #1 Data Register	176760
DAC #2 Data Register	176762

STATUS REGISTER



BIT		DESCRIPTION
00	Start	Set by software to trigger A/D coverter if ext. clock enable (Bit 01) is zero.
01	Ext. Clock Enb.	Set by software to enable external clock to trigger A/D converter. (Jumpers on the logic card select on-board multivibrator or external clock source).
02	Sequential/Random	Software conrolled. 0 = Random mode 1 = Sequential mode, A/D channel is automatically incremented at end of A/D conversion.
03, 04	Programmable Gain	Software controlled. Sets the gain of the A/D amplifier:

Bit 04	Bit 03		Gain
0	0	=	10
0	1	=	5
1	0	=	2
1	1	=	1

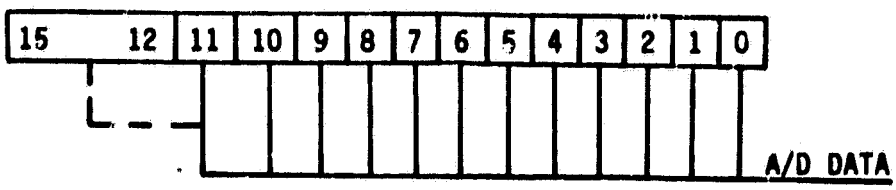
05	Reserved	Not Used
06	Intr Enable	Software controlled. Set to allow an interrupt when the done bit (07) or error bit (15) is set.
07	Done	Set by the hardware at the completion of conversion. Reset upon reading the data register by software or by "INITIALIZE".
08-13	A/D Channel Address	Controlled by software to select 1 of 64 A/D channels and initiates a conversion if Bit 01 is a zero.

13	12	11	10	9	8		
0	0	0	0	0	0	=	EMG Channel
0	0	0	0	0	1	=	Position Pot
0	0	0	0	1	0	=	Tachometer
0	0	0	0	1	1	=	Acceleration

All other channels are not used in the Linear Accelerator Application.

14	Self test	Used for maintenance purposes only.
15	Error	Set by hardware if an ADC trigger occurs before previous conversion is complete.

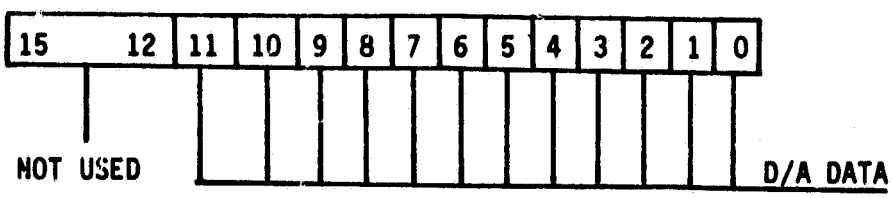
A/D DATA REGISTER



0-15 A/D Data — Read only by software. Bits 12-15 will always read the same as bit 11.

DATA CODE (OCTAL)	VOLTAGE
003777	+10V
002000	+ 5V
000000	0V
177777	0V
176000	- 5V
174000	-10V

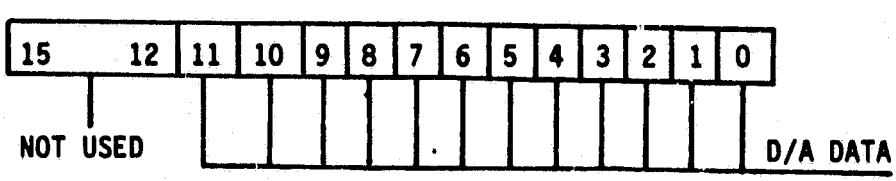
DAC #1 REGISTER



0-11 DAC #1 Data — Write only by software. Always reads all zeros.

DATA CODE (OCTAL)	VOLTAGE
003777	+ 5V
002000	+2.5V
000000	0V
007777	0V
006000	-2.5V
004000	- 5V

DAC #2 REGISTER



0-11	DAC #2 Data	Write only by software. Always reads all zeros.

DATA CODE (OCTAL)	VOLTAGE
003777	+10V
002000	+ 5V
000000	0V
007777	0V
006000	- 5V
004000	-10V

5.0 MECHANICAL DIMENSIONS

5.1 PHYSICAL DIMENSIONS

SLED (OUTSIDE DIMENSIONS)

MAIN FRAME	:	14 FT. 2 IN. LENGTH
		3 FT. 1 IN. WIDTH
		6 FT. 6 IN. HEIGHT (REAR)
		3 FT. 0 IN. HEIGHT (FRONT)
CHAIR PLATFORM	:	3 FT. 3 IN. LENGTH
		3 FT. 0 IN. WIDTH
CHAIR	:	5 FT. 2 IN. HEIGHT
		1 FT. 10 IN. WIDTH

ELECTRONIC CABINETS (OUTSIDE DIMENSIONS)

PROCESSOR CABINET	:	41 INCHES HEIGHT
		22.5 INCHES WIDTH
		22 INCHES DEPTH
CONTROL CABINET	:	52 INCHES HEIGHT
		24 INCHES WIDTH
		22 INCHES DEPTH

5.2 MECHANICAL MOVEMENT DIMENSIONS

Maximum forward movement from CENTER position switch to mechanical dead end	:	5 FT
Maximum aft movement from CENTER position switch to mechanical dead end	:	5 FT
Maximum forward movement from CENTER position switch to FORWARD position switch	:	4 FT 4 Inches
Maximum aft movement from CENTER position switch to AFT position switch	:	4 FT 4 Inches
Maximum forward movement from CENTER position switch to motor direction limit switch:		4 FT 10 Inches
Maximum aft movement from CENTER position switch to motor direction limit switch	:	4 FT 10 Inches
Distance from FWD or AFT position switch to the corresponding motor direction limit switch	:	6 Inches
Distance from FWD or AFT position switch to the corresponding mechanical dead end	:	8 Inches

6.0 CALIBRATION AND ALIGNMENT

The Motor Control Amplifier and D/A - A/D converters were calibrated at the factory and also during the development phase of the Linear Accelerator. Sometimes, however, it may be necessary to tune the components against system conditions rather than certain voltage standards.

Detailed alignment procedures are included in the manufacturer's technical manuals. The user should refer to these manuals if it is determined a complete system re-calibration is required.

System fine-tuning may be accomplished by small adjustments, as listed below, to eliminate motor creep and D/A - A/D offset.

6.1 A/D CONVERTER ADJUSTMENTS

OFFSET - Apply negative 9.9976 volts to a selected channel, and adjust the OFFSET control so that the least significant bit of the output data alternates equally between "1" and "0". Output Data = 174000/1.

NOTE: Easy access to A/D channel #3 may be achieved by disconnecting the lead from the ACCEL BNC on the control panel to the acceleration amplifier output. The input voltage may then be applied to the ACCEL BNC which is connected to the A/D converter.

RANGE - The OFFSET should be trimmed before adjusting the RANGE. Apply positive 9.9927 volts to a selected channel and adjust the RANGE control so that the least significant bit of the output data alternates equally between "1" and "0".

OUTPUT DATA = 3776/7

If the ACCEL BNC was used as the A/D channel, be sure to re-connect the ACCEL amplifier when adjustments are completed.

6.2 D/A CONVERTER ADJUSTMENTS

OFFSET - Apply an input code of 174000 and adjust the offset control so that the output of the selected DAC agrees as follows:

DAC#1 = negative 5.0 volts

DAC#2 = negative 10.0 volts

NOTE: DAC#1 output is accessed at the VELOCITY BNC, DAC#2 output is accessed at the STIMULUS BNC on the control panel.

RANGE - The OFFSET should be checked before adjusting the RANGE. Apply an input code of 003777 and adjust the RANGE CONTROL so that the output of the selected DAC agrees as follows:

DAC#1 = +4.9976 volts

DAC#2 = +9.9952 volts

6.3 MOTOR CONTROL AMPLIFIER

Motor Creep Adj. - This procedure is performed with power-on, and caution must be exercised.

The OFFSET and RANGE adjustments for the velocity D/A converter (DAC #1) should be performed prior to performing this procedure.

STEP 1 - Position the chair platform to a point where it can be easily observed for very slight creeping while standing in front of the motor control amplifier cabinet.

STEP 2 - Place the GO/STOP switch to STOP, and then the CPU/Manual switch to the CPU mode. (If any fail safe conditions exist, a RESET function must be performed).

STEP 3 - Using the processor's terminal, load 000000 into the CSR register of the DRV11-C module. The register address is 167770.

STEP 4 - Using the processor's terminal, load 000000 into the velocity D/A converter register (address 176760).

STEP 5 - Connect a voltmeter to the velocity BNC on the control panel and ensure that the velocity signal is zero volts, and if not, repeat STEP 4.

STEP 6 - Using the processor's terminal, load 000002 into the CSR register (address 167770).

This action should release the BRAKE. If not, the RESET function must be performed and fail safe conditions cleared.

STEP 7 - Place the GO/STOP switch to the GO position and observe the chair platform for creep.

STEP 8 - If necessary, adjust potentiometer P6 on the motor control amplifier to eliminate all movement of the chair.

STEP 9 - When adjustment is complete, place the GO/STOP switch in the STOP position.

7.0 MAINTENANCE

7.1.0 THEORY OF OPERATION

7.1.1 FAIL SAFE DETECTOR (LOGIC CARD #C)

Reference the Schematic Drawing, Number TH8115-1E01.

This circuit card monitors the various fail safe, and system malfunction signals which are asserted whenever a condition exists which necessitates a sled movement shut-down. These signals are: IR Beam tripped, SMU Power failure, brake pressure, and runaway. When one or more of these inputs are asserted, the detection logic output turns off a relay. The relay contacts are wired to the "inhibit" terminals on the motor control amplifier, and a second pair of contacts are connected to the brake solenoid. The opening of the relay contacts inhibits current to the motor and activates the brake.

Each of the four input signals is routed to a latching flip-flop (IC's 5 and 8) which is triggered by a clock pulse (IC10 pin 8) whenever the input signal is at the logic zero level. The "Q" output of the flip-flop goes to a logic one level on the low-to-high transition of the clock pulse, and remains in the set state until manually reset via the reset switch on the control panel.

The $\overline{\text{"Q"}}$ output is used to turn on an indicator lamp on the control panel through lamp driver IC19. The "Q" output is gated through to IC18 pin 11 which is the relay driver. A logic one level at IC14 pin 8 turns the relay off.

Each of the flip-flop detectors is also gated with a "bypass" function. If it is desired to bypass, or prevent, a selected condition from shutting down the sled movement, the operator may enable the bypass by setting an appropriate switch located on logic card Y. Normally this bypass function is only activated during maintenance or checkout procedures.

The clock pulse is derived from IC10 and has a 50usec period determined by the capacitor connected to pins 1 and 2. The clock pulse is monitored by a re-triggerable one-shot IC11. Its output pin 5 will be a logic zero if the clock should fail to operate. A clock failure will also turn off the relay driver forcing a shutdown.

The relay may also be deactivated by the processor program. When the CPU/Manual switch is in the CPU mode, the program asserts the CSR1 bit (Logic One) to turn the relay on. The gating logic providing this function is connected to IC20 pin 2. If the CPU/Manual switch is in the manual mode, the relay is controlled by only the fail safe detector logic.

Whenever a fail safe condition exists, the CPU/Manual switch is in MANUAL position, or the GO/STOP switch is in the STOP position, flip-flop IC3 generates the "REQ A" signal at IC1 pin 6. This signal is used to notify the CPU program that sled movement has been shutdown. Normally, the assertion of REQ A causes a program interrupt, and is cleared at the end of the interrupt service routine by the processor asserting the "INIT" or "DATA XMITTED" signals.

7.1.2 LAMP DRIVERS (LOGIC CARD #F)

Reference Schematic Drawing, Number TH8115-1E02.

This circuit card consists primarily of lamp drivers (75451) for the various indicator lamps on the control panel. The position switches are routed to switch debouncer circuits (74279) IC6. The output pins 4,7, and 13 are at a logic one level when the associated switch is closed.

The inputs from the IR perimeter beams are normally open contacts of a relay within the IR beam source boxes. When the beam is interrupted, these contacts close supplying ground to the associated input to this circuit card. The four IR beam inputs are or'd together at IC2 pin 8 so that any one of the four being tripped will produce the actuating signal (Logic Card pin 9) to the fail safe detector, Card C.

The "clear" signal at card pin T is generated only with certain conditions being attained as controlled by IC9. In the manual mode, the clear signal is asserted only if the RESET switch is activated when the GO/STOP switch is in the STOP position. If the CPU/Manual switch

is in the CPU mode, the CPU must clear CSR1 and the operator must place the GO/STOP switch in the STOP mode in order for the RESET switch to generate the "clear" command. This gating logic is incorporated as a safety feature to prevent the clearing of fail safe conditions with a velocity signal applied to the sled motor.

7.1.3 RUNAWAY DETECTOR (LOGIC CARD #J)

Reference the Schematic Drawing, Number TH8115-1E03.

This circuit card performs two functions: (1) detects a "runaway" situation by monitoring the velocity and acceleration signals, and comparing the amplitudes of each with predetermined levels; (2) selects the scaling of the velocity signal as determined by the mode of operation and/or processor command.

The output of the accelerometer amplifier is compared with a positive reference voltage by IC13 (UA710 voltage comparator). The comparator produces a logic one level at ICI pin 10 whenever the acceleration signal is more positive than the reference voltage at IC13 pin 3. The reference voltage is jumpered from IC16 which is a voltage divider network of series resistors. The voltage taps of IC6 provide hardware-programming for the maximum acceleration signal before a runaway condition is detected at IC1 pin 10.

In order to detect excessive acceleration in the opposite direction, the acceleration signal is inverted by the unity-gain amplifier IC15 (MC1458). Its output is also compared to a positive reference voltage by IC14. The outputs of the two comparators are routed to IC3

pin 8 (or gate) which produces a logic zero level at IC4 pin 2 signifying a runaway condition whenever the acceleration exceeds predetermined levels.

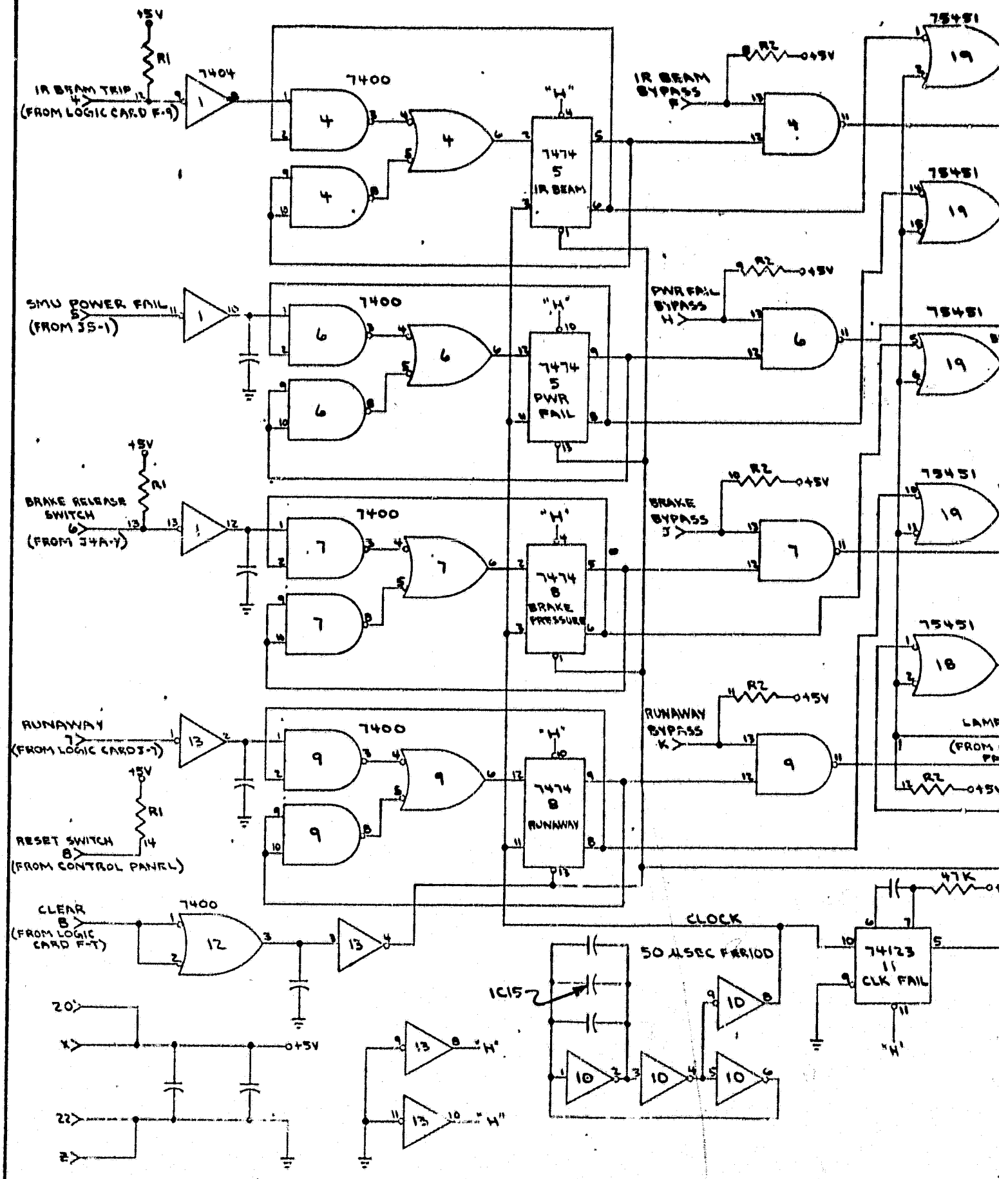
The velocity signal is compared in a likewise manner as the acceleration signal, however, the comparator outputs IC1 pin 6 and IC1 pin 8 are gated with the FORWARD and AFT position switches at IC2 pin 6 and 8. This allows the runaway signal to be asserted only if the velocity signal exceeds the reference voltage when one or the other position switch is turned on.

The velocity signal is scaled down through one of two voltage attentuators. The Lo-scale attenuates by a factor of 5:1 and the Hi scale has a ratio of 2:1. The switching from one scale to the other is facilitated by a relay (IC10), which is controlled by the state of the CPU/Manual switch and CSRØ. In the manual mode the Lo-scale is always automatically selected by the gating of IC2 pin 3. In the CPU mode, the state of CSRØ determines the selection (Logic Zero = Lo-scale, Logic One = Hi-scale).

APPENDIX

LINEAR ACCELERATOR
DRAWING LIST

DRAWING NUMBER	TITLE
TH8115-1E01	Schematic, Fail Safe Detector, Logic Card C
TH8115-1E02	Schematic, Lamp Drivers, Logic Card F
TH8115-1E03	Schematic, Runaway Detector, Logic Card J
TH8115-1E04	Schematic, Fail Safe Relay & Fail Safe Bypass (Logic Card Y)
TH8115-1E05	Schematic, Motor Control
TH8115-1E06	Schematic, Sled Cabling (J4A)
TH8115-1E07	Schematic, Sled Cabling (J4B)
TH8115-1E08	Schematic & Wire List, Control Panel
TH8115-1E09	LSI-11 Configuration & Wiring Diagram
TH8115-1E10	Wiring Diagram, Power Supplies
TH8115-1E11	Wire List, Sled Cable (P4A & P4B)



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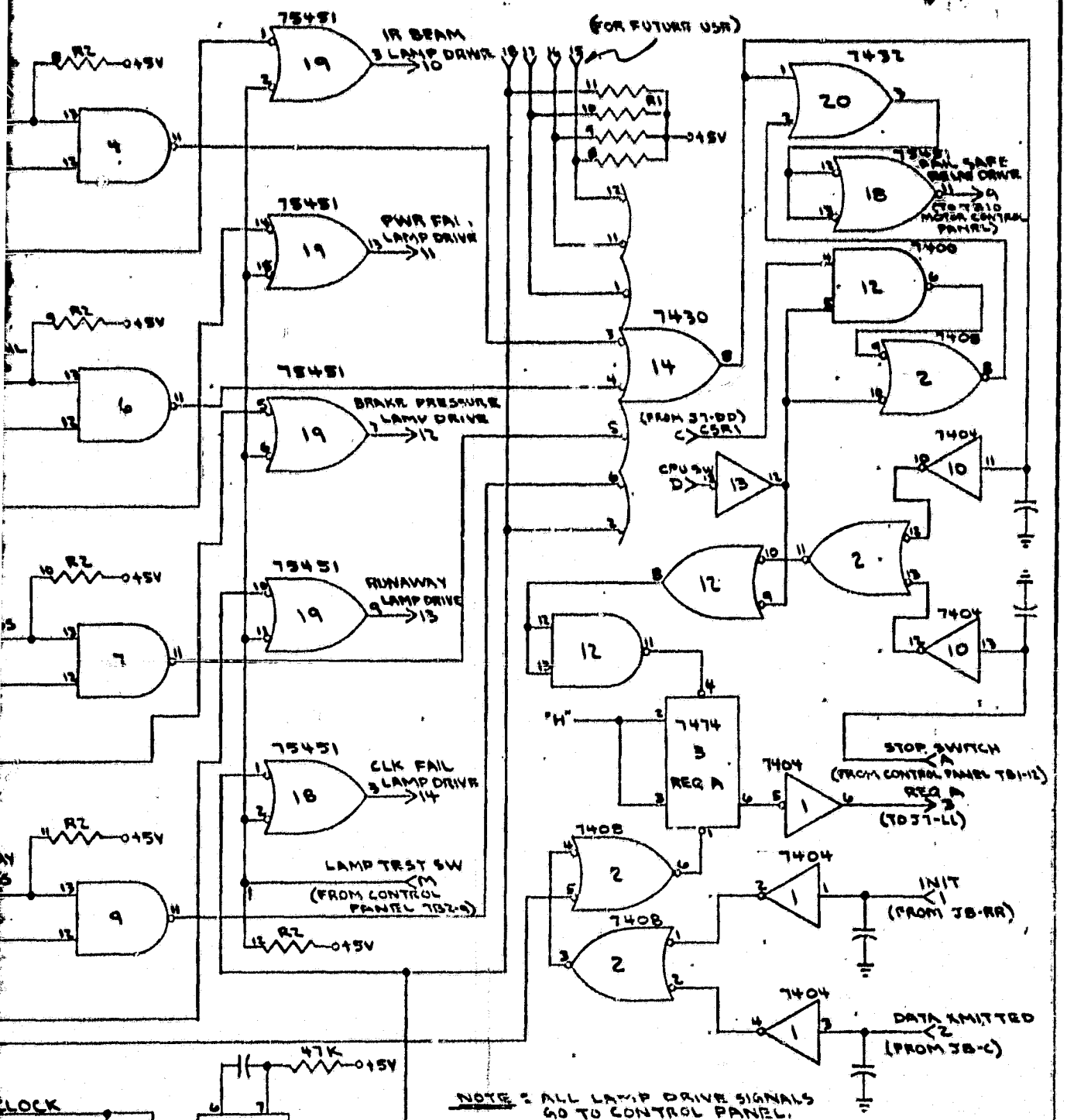

TECHNOLOGY INCORPORATED LIFE SCIENCES DIVISION HOUSTON, TEXAS 77058	
DRAWN BY: M.H. UTLEY	DATE: 11-17-80
DESIGN ENG.	
PROJ. ENG.	
TITLE: SCHEMATIC FAIL SAFE DETECTOR (LOGIC CARD C) LINEAR ACCELERATOR	
DWG. NO.: TH8115-1E01	
SHEET: 1 OF 1	

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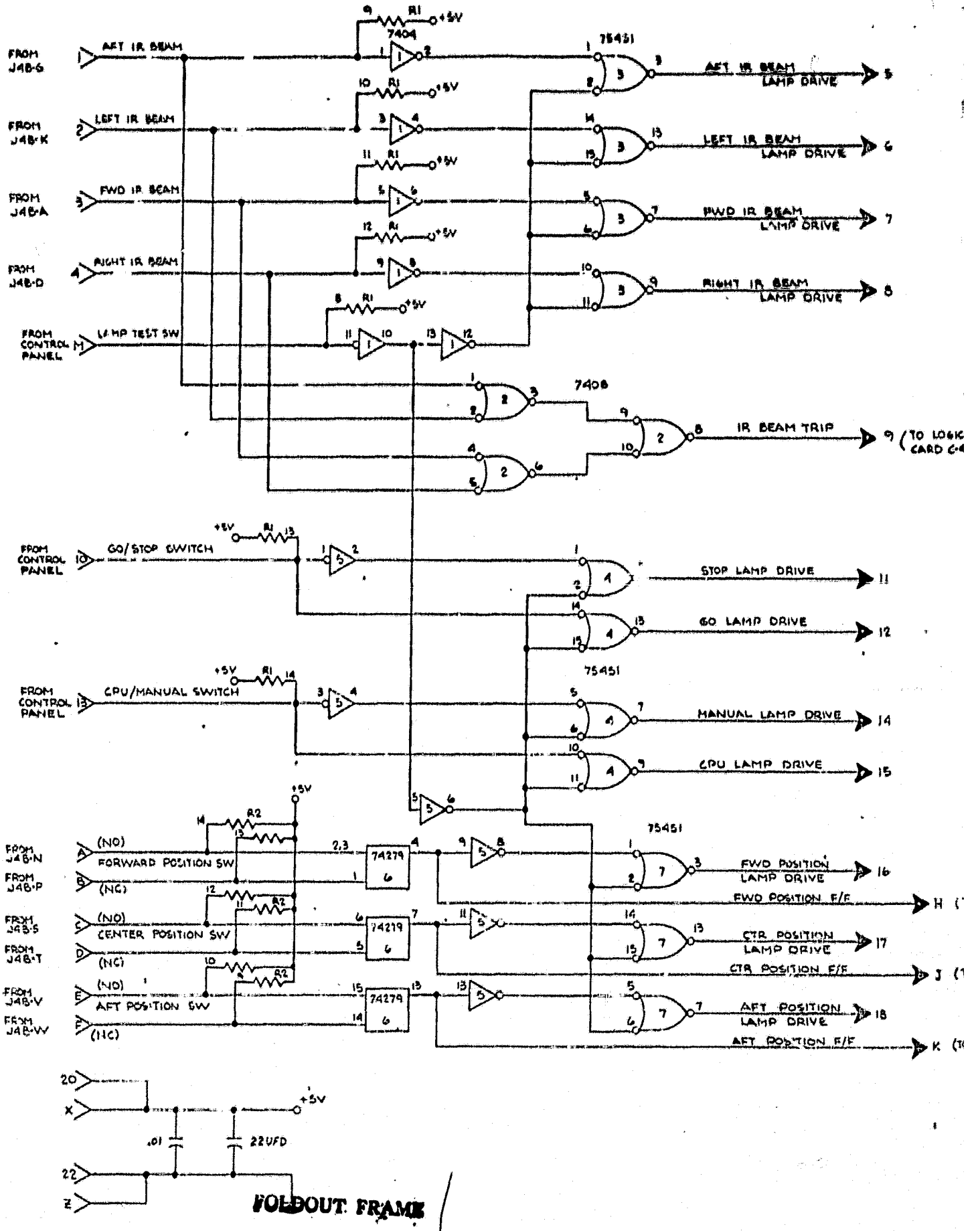

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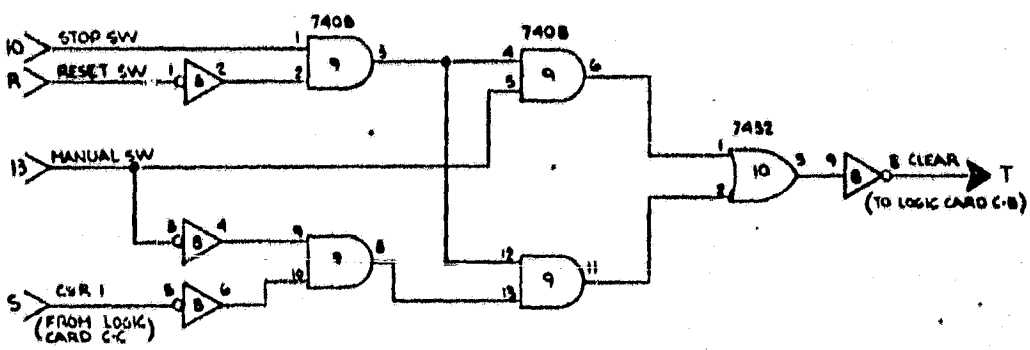
9 (TO LOGIC CARD C-4)



11

12

14

15

16

H (TO LOGIC CARD J-H)

17

J (TO LOGIC CARD J-J, NOT USED)

18

K (TO LOGIC CARD J-K)

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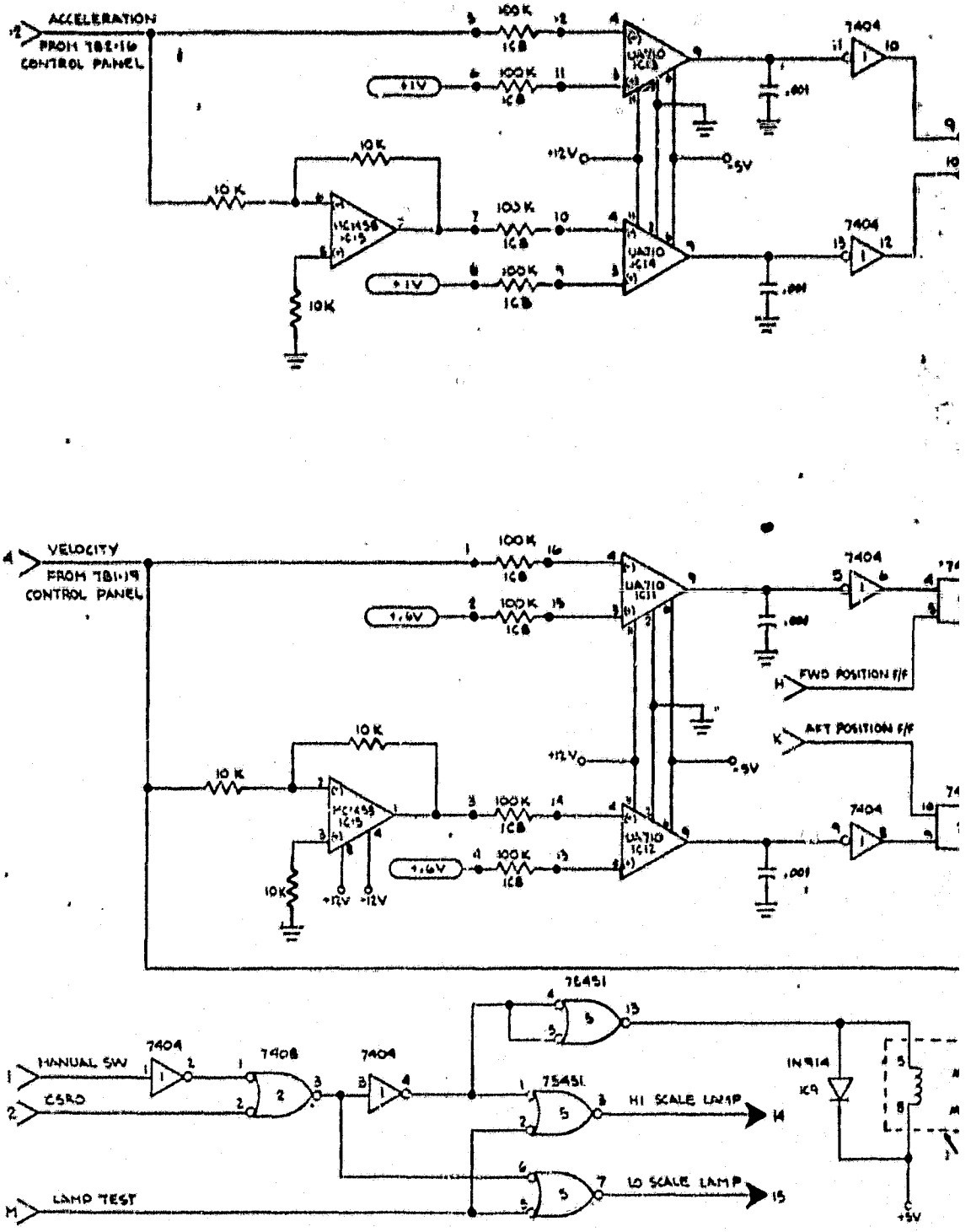
NOTES:
1.- ALL LAMP DRIVE SIGNALS GO TO THE CONTROL PANEL
2.- RESISTORS ARE 4.7K

TECHNOLOGY, INC. LIFE SCIENCES DIVISION HOUSTON, TEXAS	
TITLE	LINEAR ACCELERATOR SCHEMATIC LAMP DRIVERS (LOGIC CARD F)
DWG NO.	7H8115-1E02



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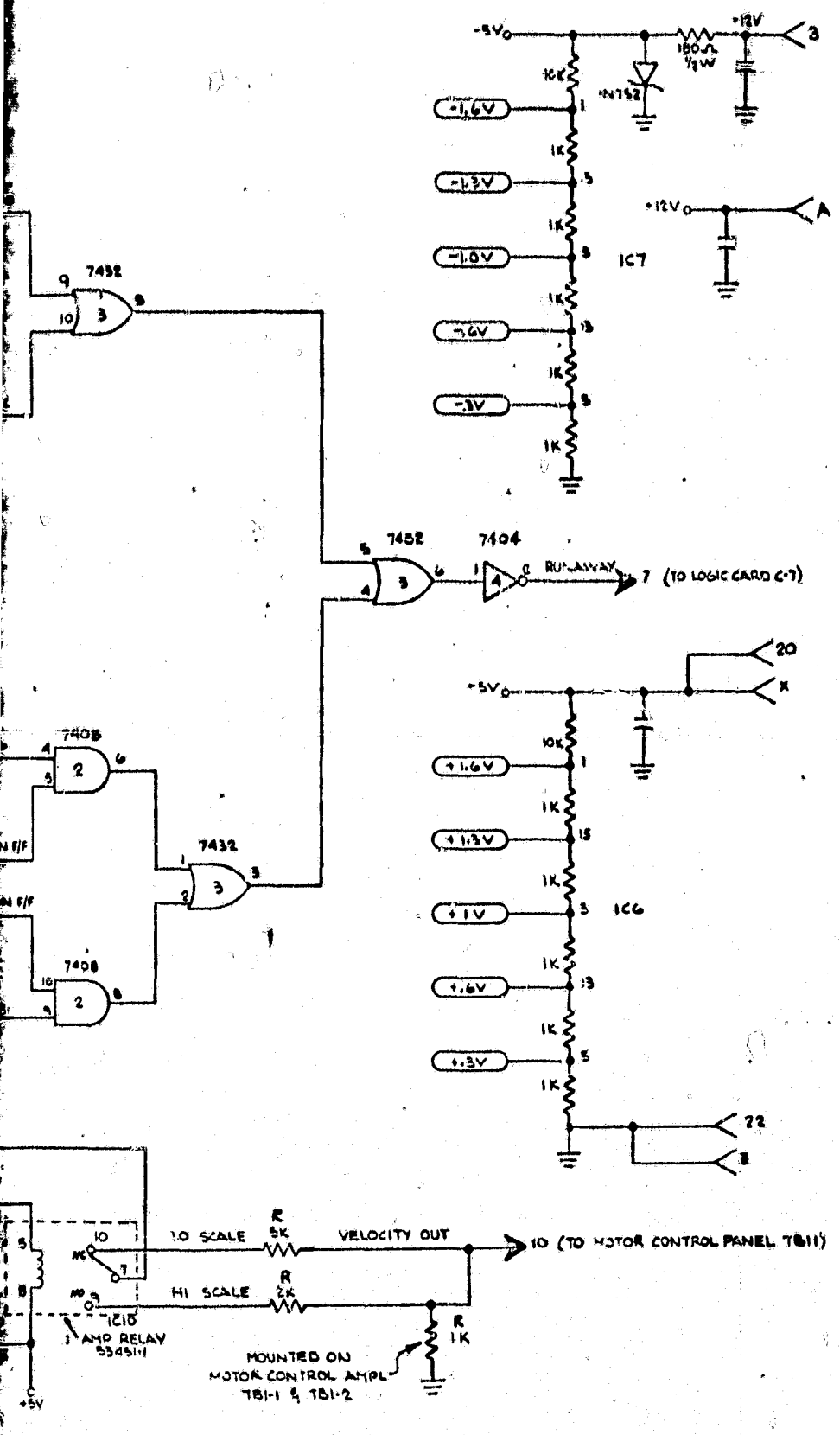

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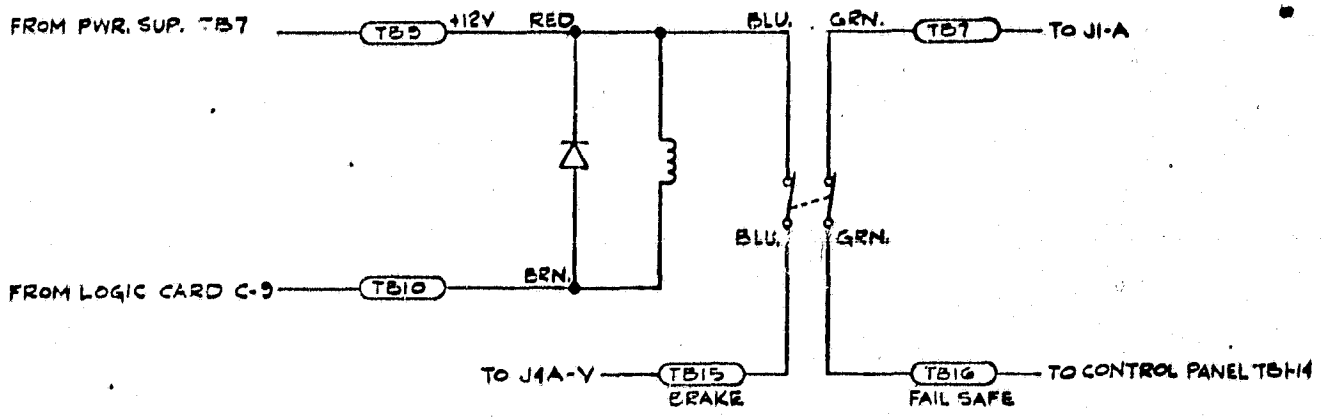
TECHNOLOGY, INC.
LIFE SCIENCES DIVISION
HOUSTON, TEXAS

TITLE LINEAR ACCELERATOR
SCHEMATIC
RUNAWAY DETECTOR
(LOGIC CARD J)

DWG NO. 7H8115-1603



SCHEMATIC
FAIL SAFE RELAY
SEE NOTES 3&4

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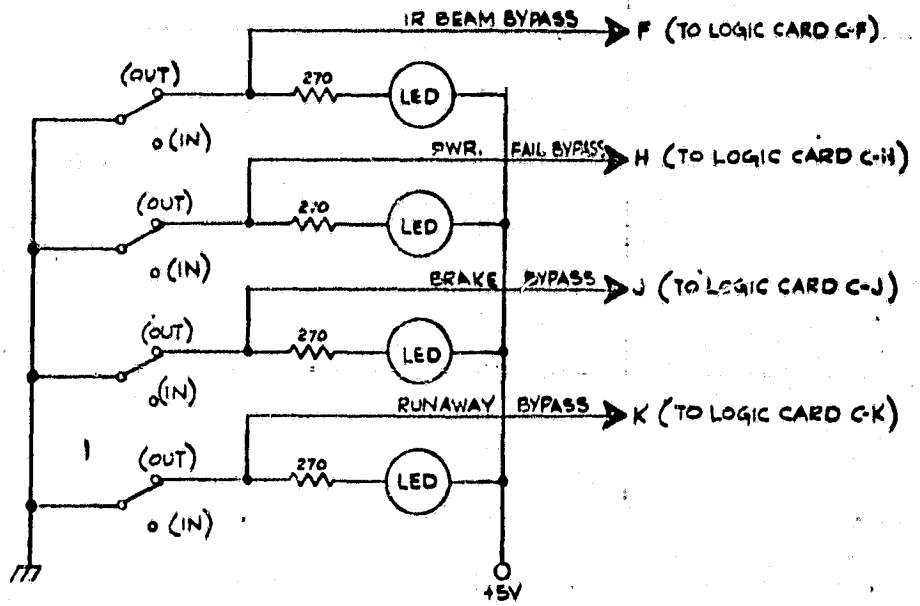


SCHEMATIC
FAIL SAFE BYPASS
(LOGIC CARD Y)
SEE NOTES 1 & 2

FOLDOUT FRAME 2

NOTES:

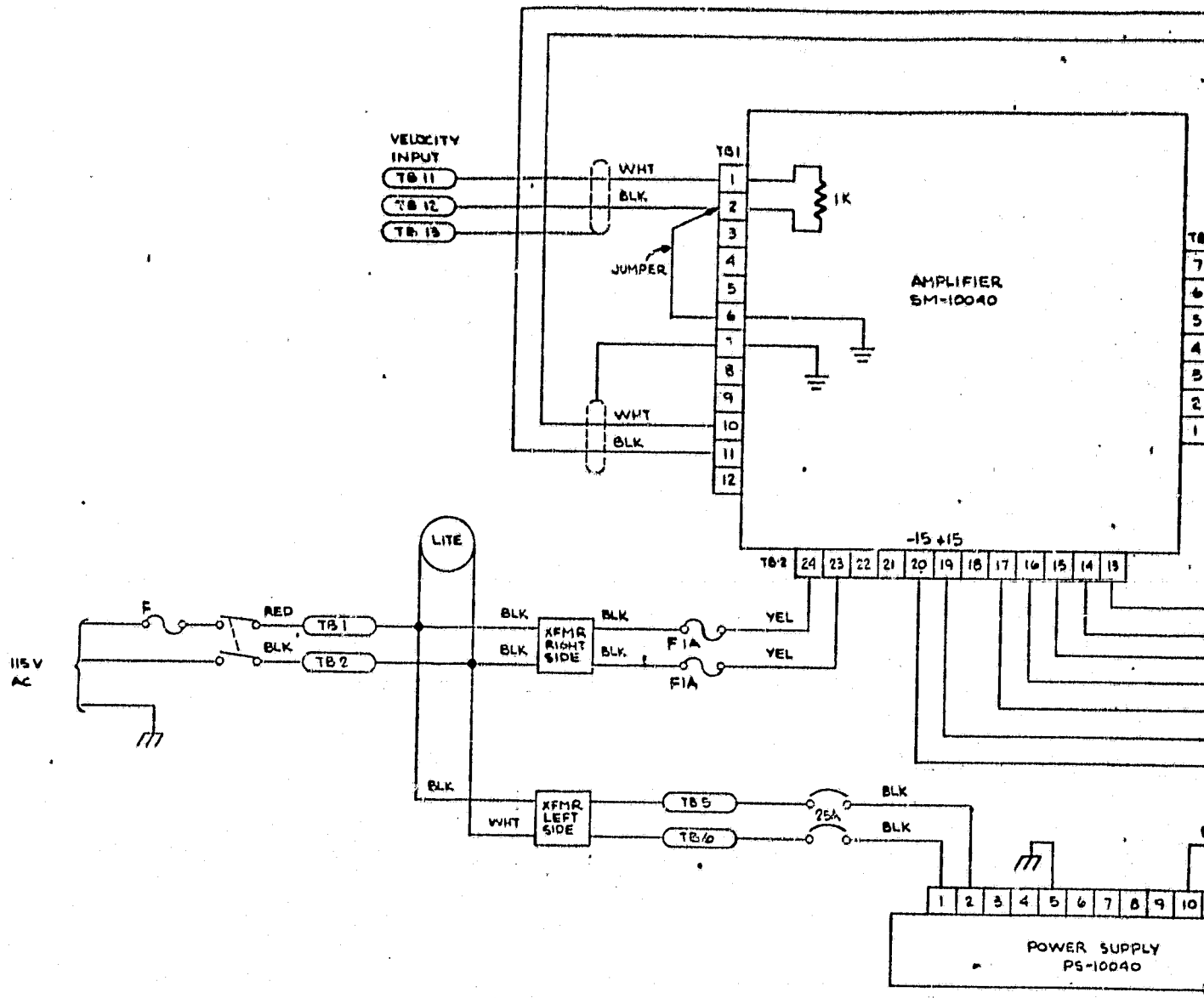
1.-LED IS ON WHEN CKT. IS BYPASSED

2.-THE BYPASS CKT. CARD MAY BE REMOVED FROM CARD CAGE IF DESIRED, WITHOUT INTERRUPTING THE OPERATION OF OTHER ELECTRONICS.

3.-RELAY MOUNTED ON MOTOR CONTROL PANEL CONTACTS ARE NORMALLY CLOSED.

4.-(TBx) DENOTES TERMINAL BD. ON MOTOR CONTROL PANEL.

TECHNOLOGY, INC. LIFE SCIENCES DIVISION HOUSTON, TEXAS	
TITLE	LINEAR ACCELERATOR SCHEMATIC FAIL SAFE RELAY & FAIL SAFE BYPASS (LOGIC CARD Y)
DWG NO.	TH8115-1E04



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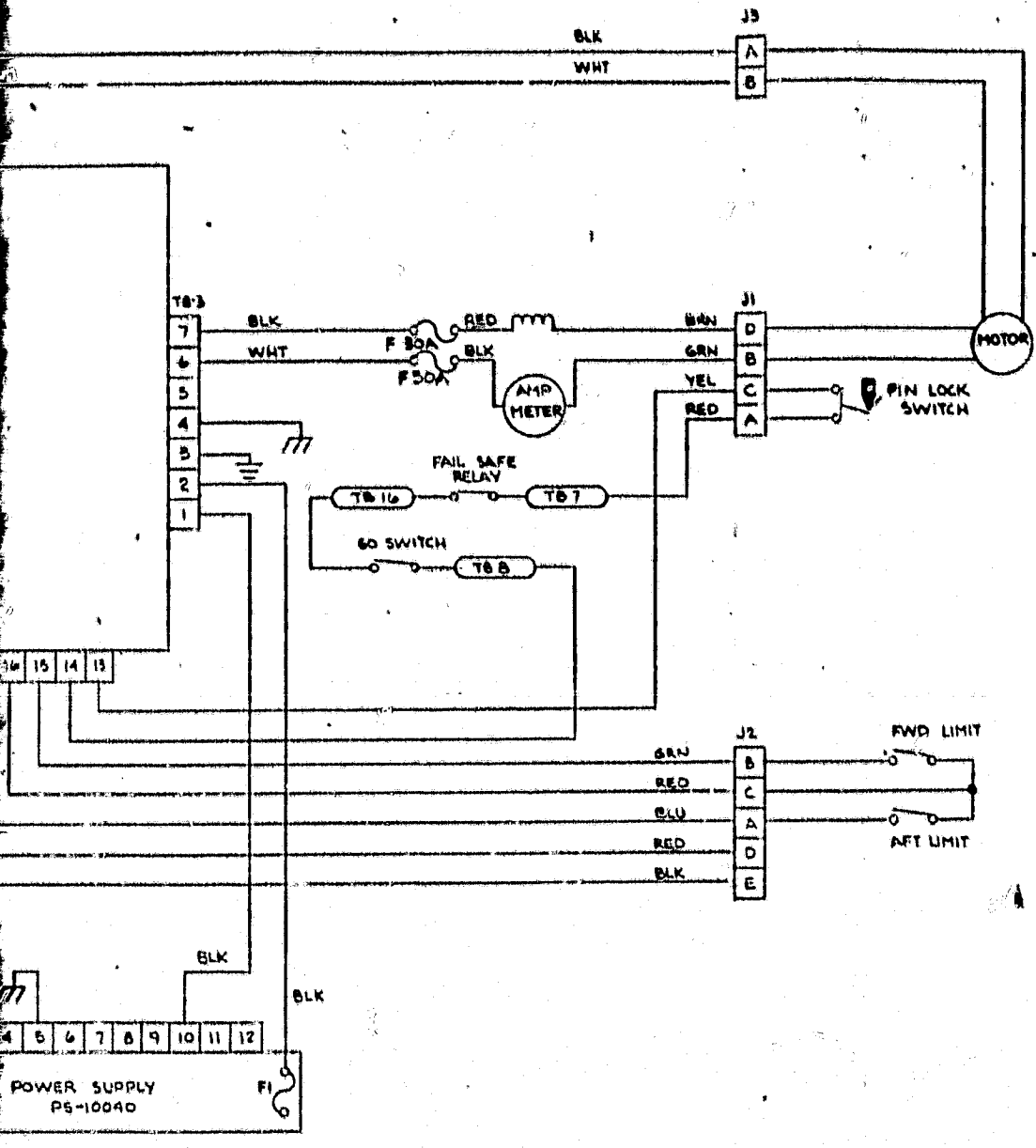

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NOTES:

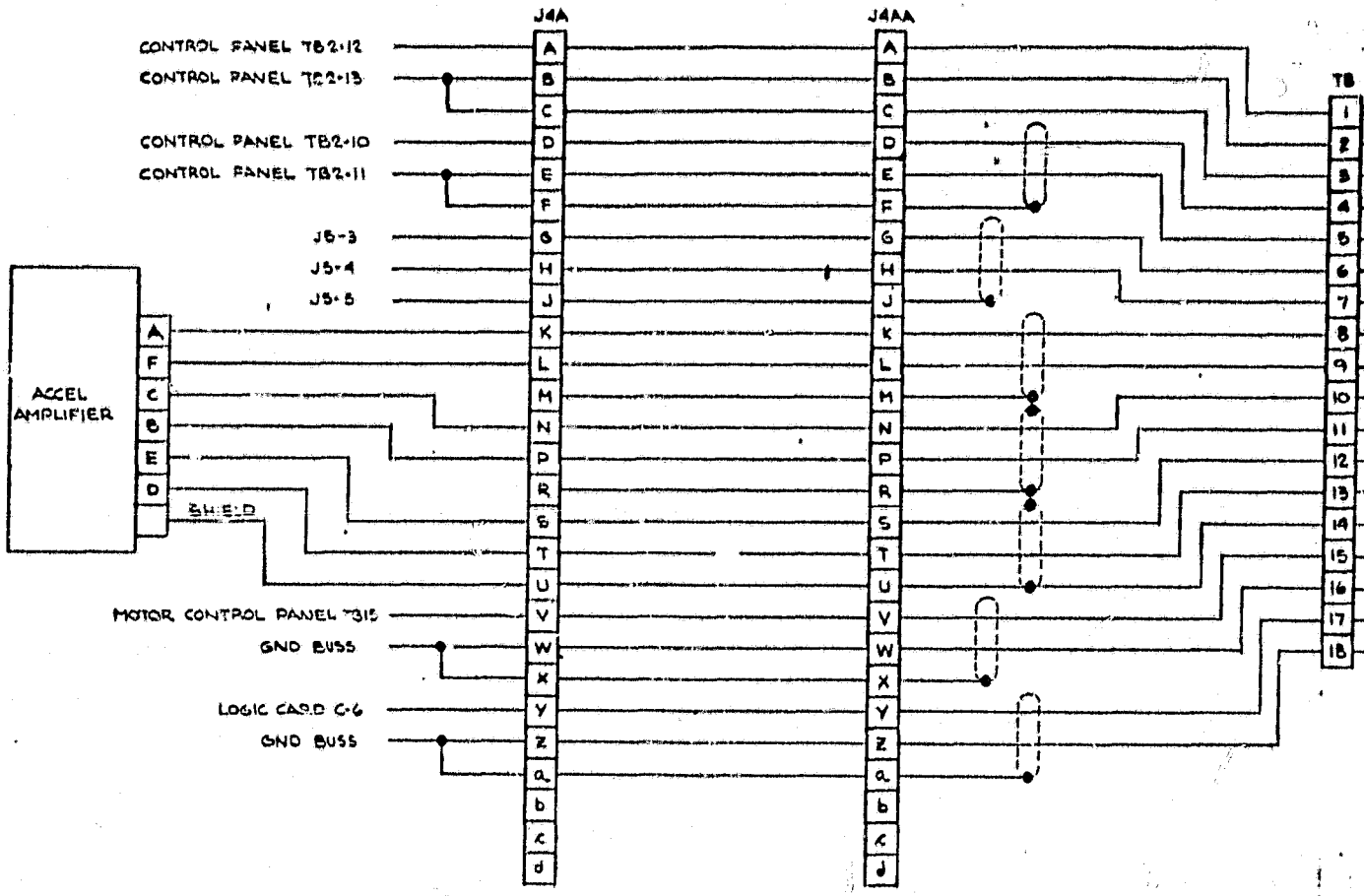
1.- ALL WIRING SHOWN FOR A POSITIVE (+) VELOCITY INPUT TO PRODUCE A FORWARD MOVEMENT.
TO SWITCH POLARITY, REVERSE TB3-6 & 7 AND TB1-10 & 11 OF AMPLIFIER.

2.- (TB X) DENOTES TERMINAL BOARD LOCATED ON MOTOR CONTROL PANEL

TECHNOLOGY, INC.
LIFE SCIENCES DIVISION
HOUSTON, TEXAS

TITLE LINEAR ACCELERATOR SCHEMATIC MOTOR CONTROL

DWG NO. THB115-1E2C



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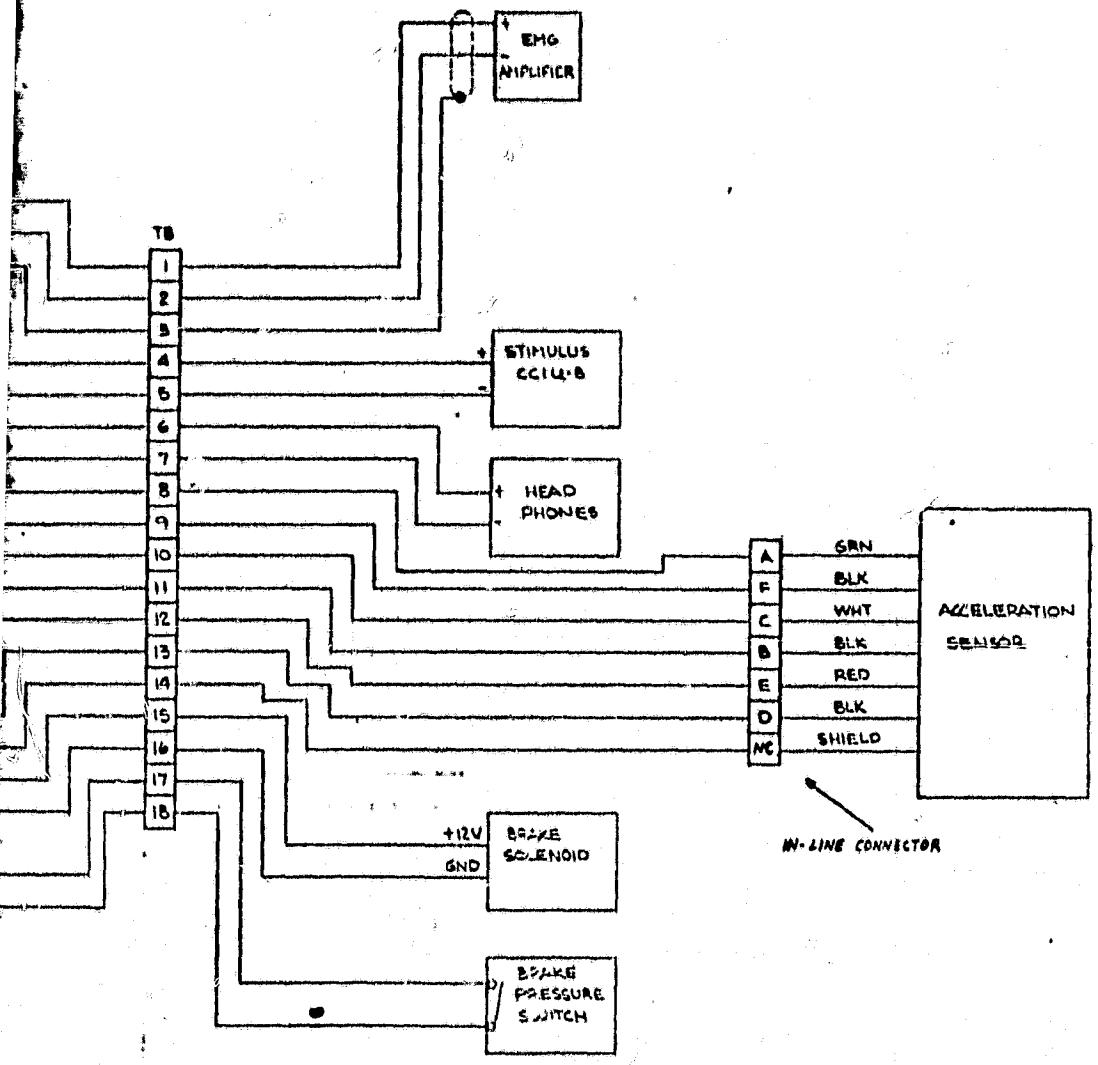

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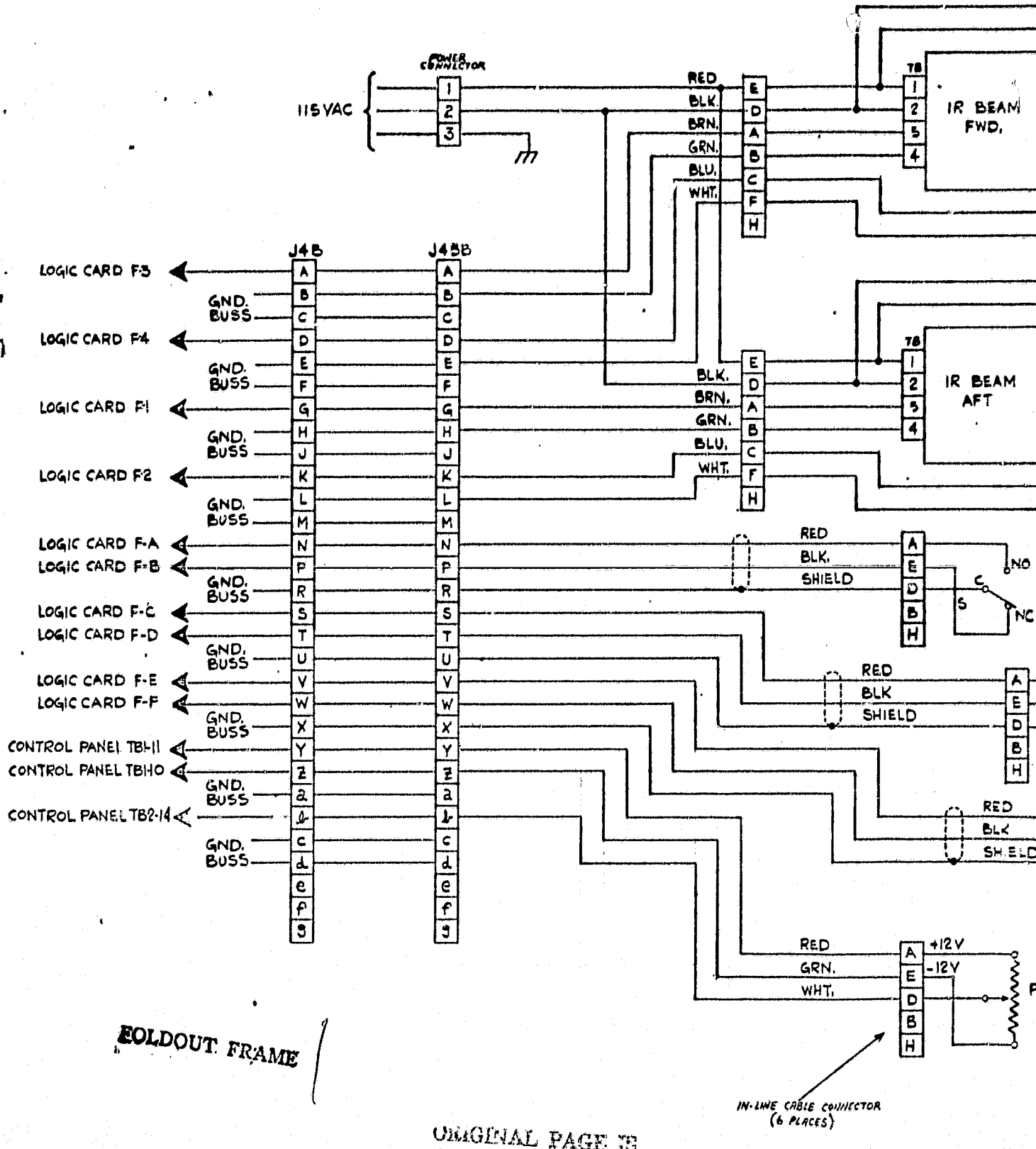
TECHNOLOGY, INC.
LIFE SCIENCES DIVISION
HOUSTON, TEXAS

TITLE
LINEAR ACCELERATOR
SCHEMATIC
SLED CABLING (J4A)

DWG NO. THB115-1E06



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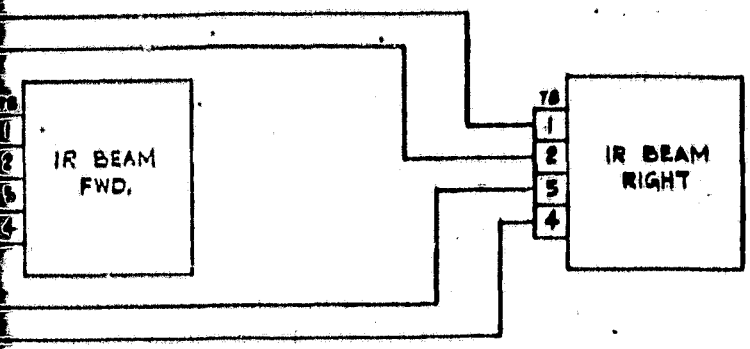

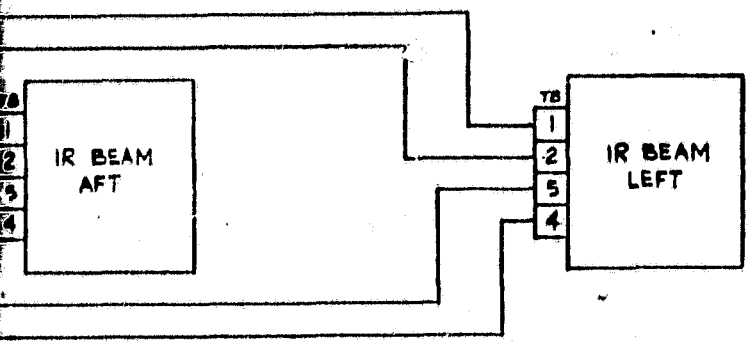

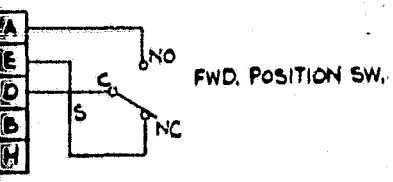

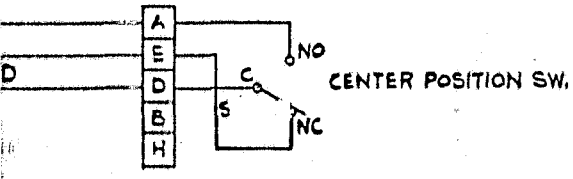

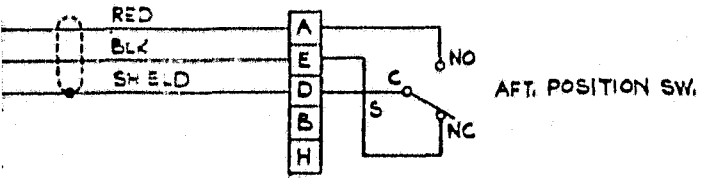

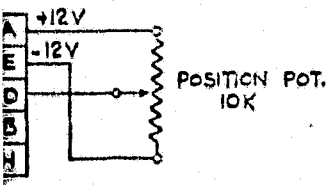

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	TECHNOLOGY, INC. LIFE SCIENCES DIVISION HOUSTON, TEXAS
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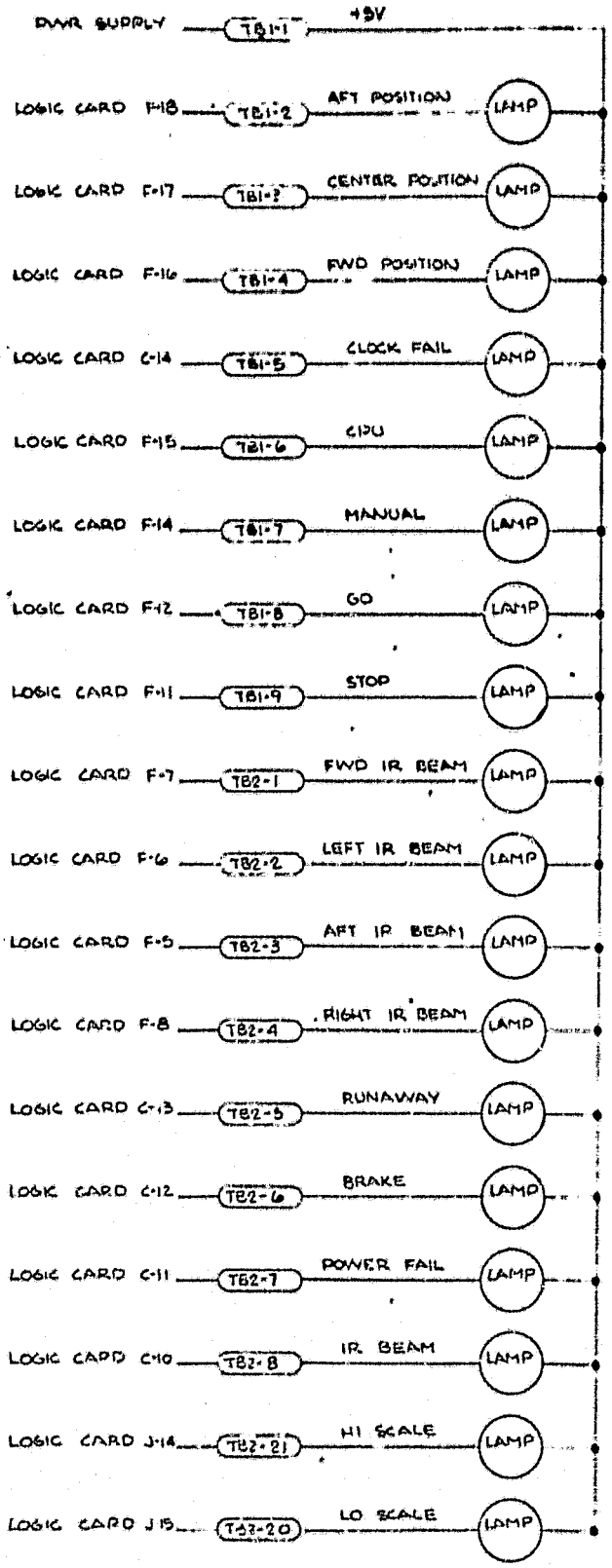
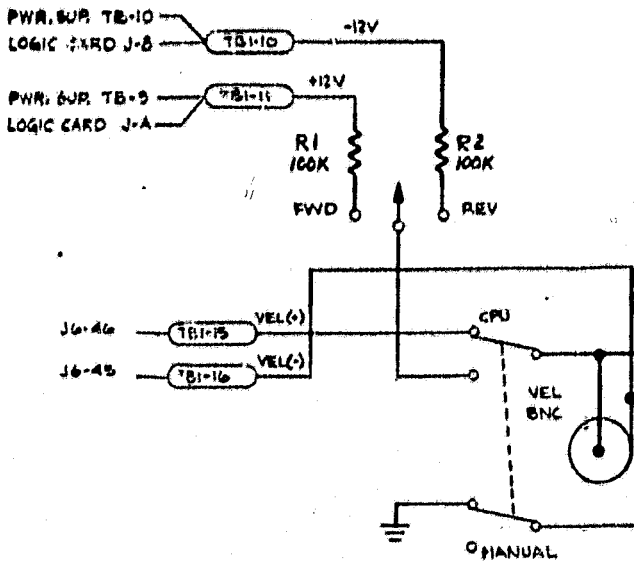
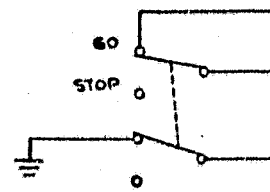
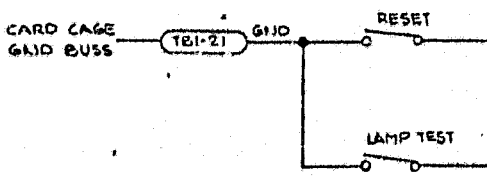
DWG NO.	THB115-1E07









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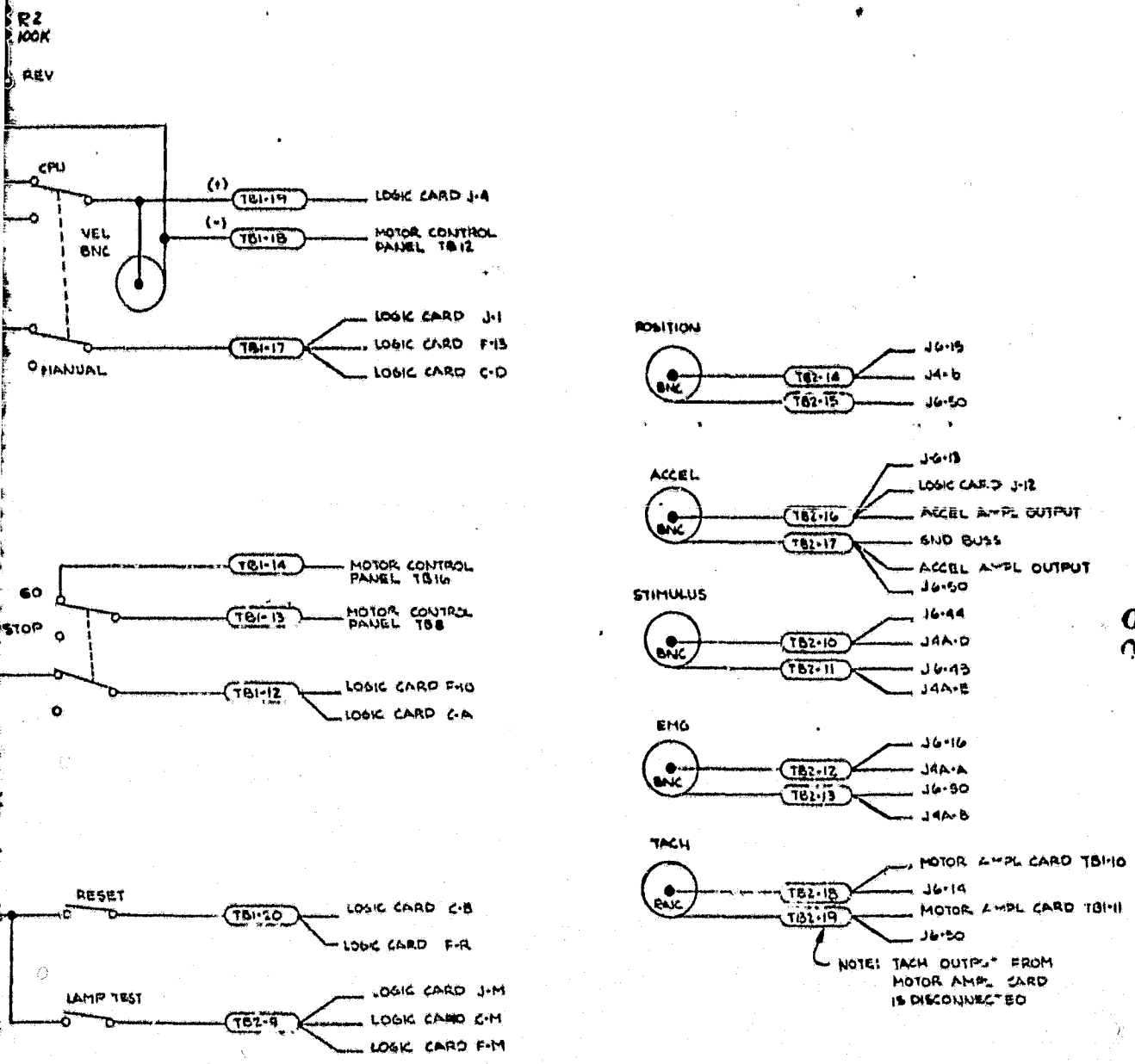

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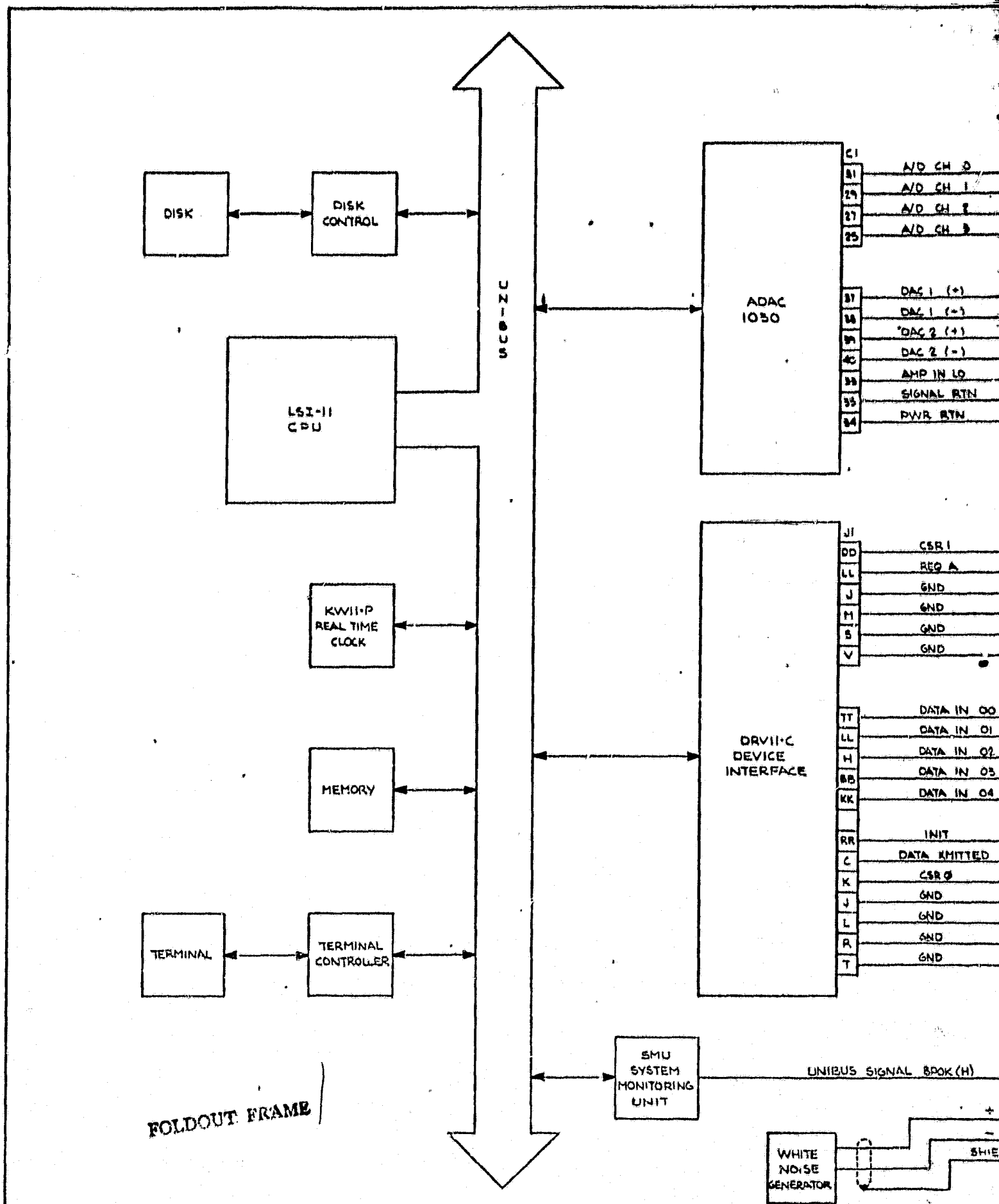
TECHNOLOGY, INC.
LIFE SCIENCES DIVISION
HOUSTON, TEXAS

TITLE
LINEAR ACCELERATOR
SCHEMATIC & WIRE LIST
CONTROL PANEL

DWG NO. THB115-1E08



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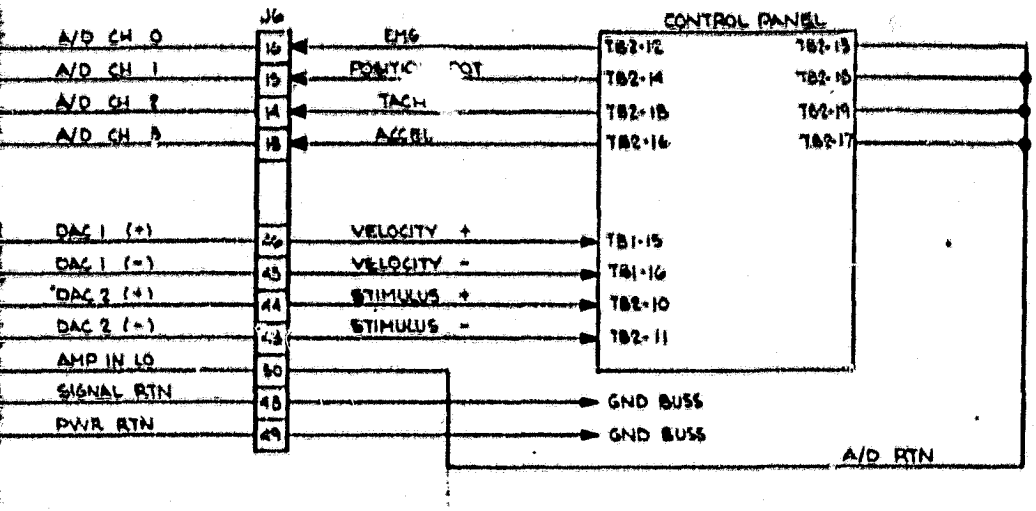
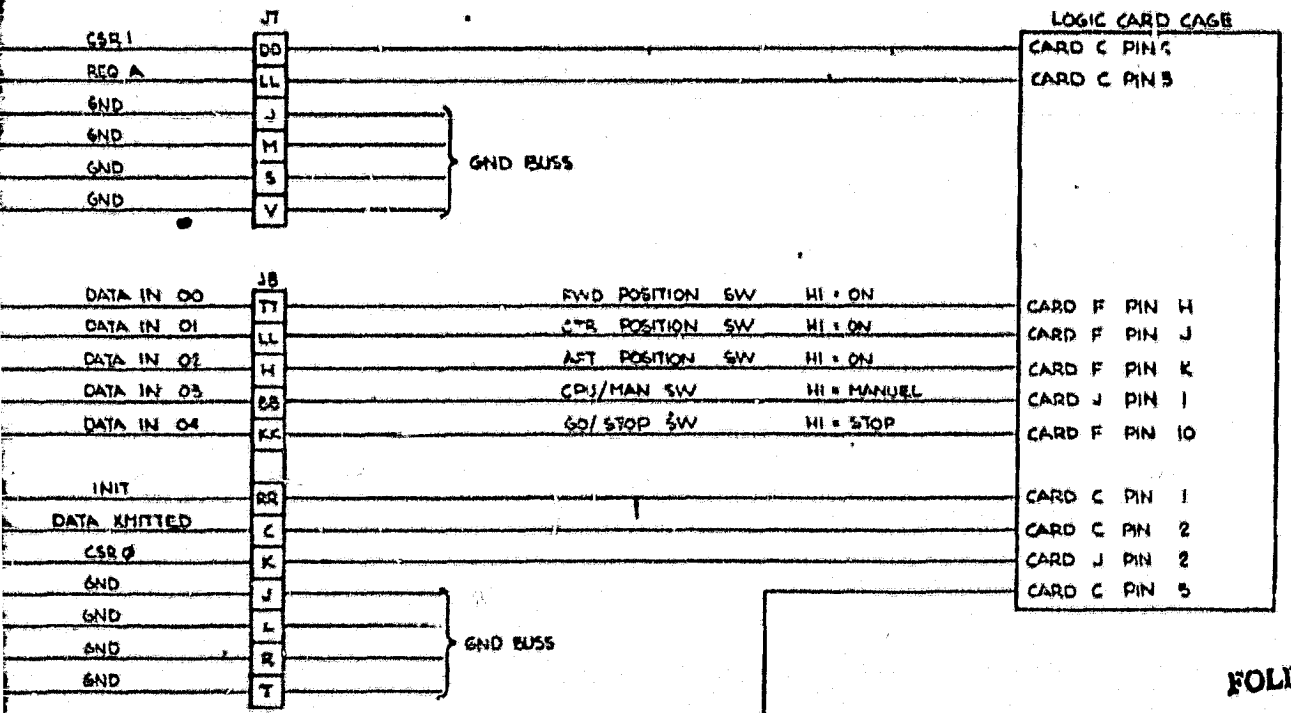
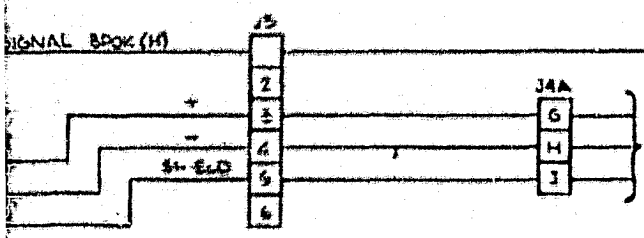




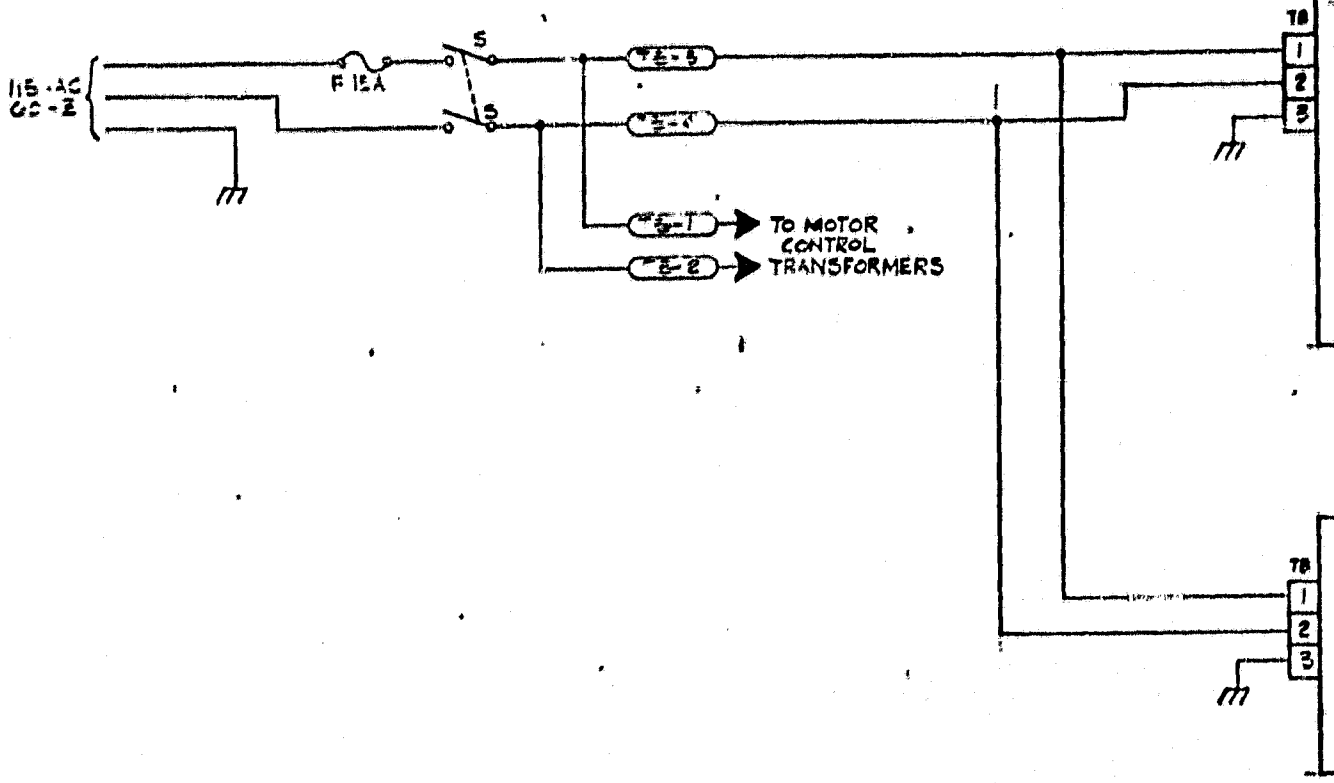
FOLDOUT FRAME



TECHNOLOGY, INC.
LIFE SCIENCES DIVISION
HOUSTON, TEXAS

TITLE
LINEAR ACCELERATOR
LSI-II CONFIGURATION
WIRING DIAGRAM

DWG NO. TH8115-1E09



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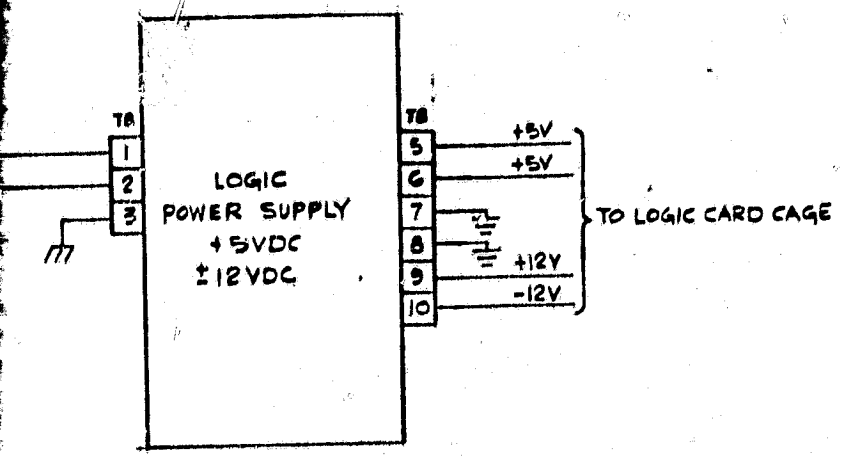
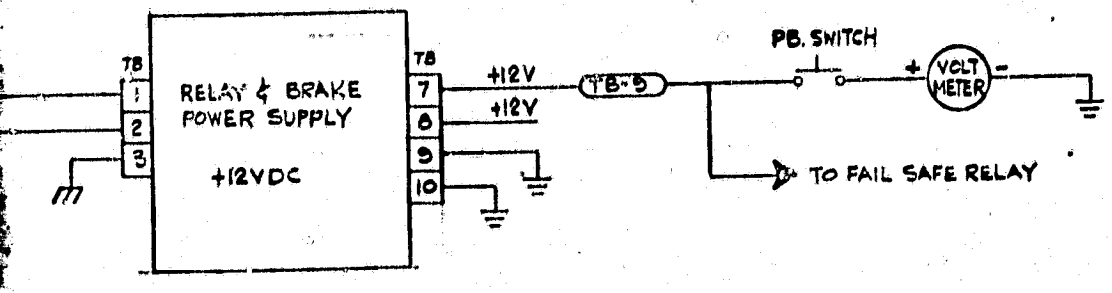
REVISIONS		
LTR	DESCRIPTION	DATE





FOLDOUT FRAME 2

NOTES:

1.- (TB-X) = DENOTES TERMINAL BD. ON MOTOR CONTROL PANEL

2.- LOGIC GROUND AND CHASSIS GROUND ARE CONNECTED TOGETHER.

TECHNOLOGY, INC. LIFE SCIENCES DIVISION HOUSTON, TEXAS	
TITLE	LINEAR ACCELERATOR WIRING DIAGRAM POWER SUPPLIES
DWG NO.	TNB115-1E10

NO.	COLOR	FROM	TO	SIGNAL
1	BRN	P4A-A	P4AA-A	EMG +
2	RED	-B	-B	EMG -
3	SHIELD	-C	-C	GND
4	BLU	-D	-D	STIMULUS +
5	RED	-E	-E	STIMULUS -
6	SHIELD	-F	-F	GND
7	WHT	-G	-G	WHITE NOISE +
8	RED	-H	-H	WHITE NOISE -
9	SHIELD	-J	-J	GND
10	BLK	-K	-K	ACCEL.
11	RED	-L	-L	ACCEL.
12	SHIELD	-M	-M	
13	BLK	-N	-N	ACCEL.
14	GRN	-P	-P	ACCEL.
15	SHIELD	-R	-R	
16	BLU	-S	-S	ACCEL.
17	BLK	-T	-T	ACCEL.
18	SHIELD	-U	-U	
19	BRN	-V	-V	BRAKE SOL. +12V
20	BLK	-W	-W	BRAKE SOL. GND
21	SHIELD	-X	-X	
22	YEL	-Y	-Y	BRAKE PRESSURE SW (NO)
23	BLK	-Z	-Z	BRAKE PRESSURE SW (C)
24	SHIELD	-a	-a	
25	BLU	-b	-b	
26	WHT	-c	-c	
27	SHIELD	-d	-d	
28	WHT	P4B-A	P4BB-A	FWD IR BEAM SW.
29	BLK	-B	-B	FWD IR BEAM GND
30	SHIELD	-C	-C	
31	BRN	-D	-D	RIGHT IR BEAM SW.
32	GRN	-E	-E	RIGHT IR BEAM GND
33	SHIELD	-F	-F	
34	WHT	-G	-G	AFT IR BEAM SW.
35	GRN	-H	-H	AFT IR BEAM GND
36	SHIELD	-J	-J	
37	BLU	-K	-K	LEFT IR BEAM SW.
38	GRN	-L	-L	LEFT IR BEAM GND
39	SHIELD	-M	-M	
40	OR	-N	-N	FWD POSITION SW (NO)
41	RED	-P	-P	FWD POSITION SW. (NC)
42	SHIELD	-R	-R	FWD POSITION SW. (C)
43	YEL	-S	-S	CTR. POSITION SW. (NO)
44	RED	-T	-T	CTR. POSITION SW (NC)
45	SHIELD	-U	-U	CTR. POSITION SW (C)
46	OR	-V	-V	AFT POSITION SW. (NO)
47	BLK	-W	-W	AFT POSITION SW. (NC)
48	SHIELD	-X	-X	AFT POSITION SW. (C)
49	YEL	-Y	-Y	POSITION POT +12V
50	GRN	-Z	-Z	POSITION POT -12V
51	SHIELD	-a	-a	GND
52	OR	-b	-b	POSITION POT WIPER
53	GRN	-c	-c	GND
54	SHIELD	-d	-d	GND
55	GRN	-e	-e	
56	RED	-f	-f	
57	SHIELD	-g	-g	

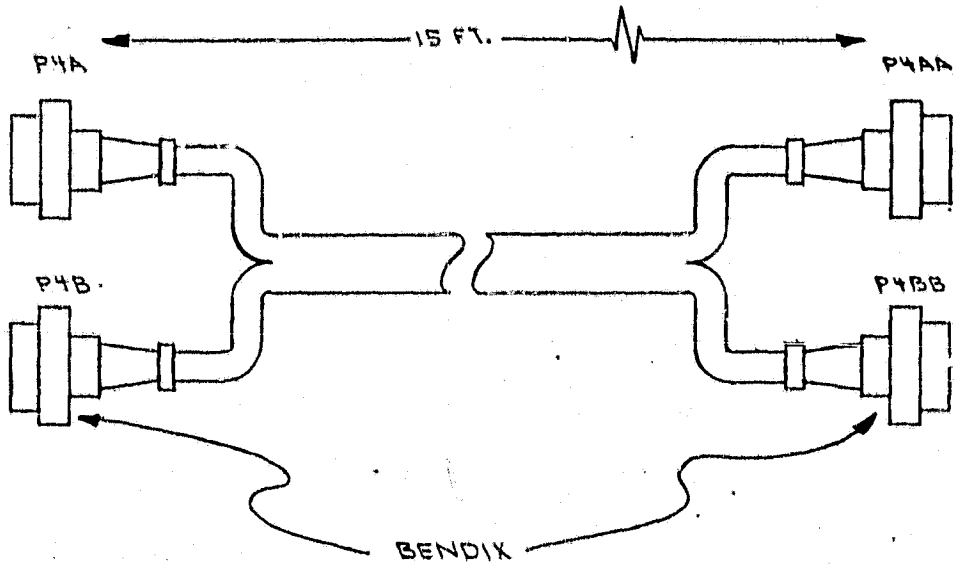
MOVING CHAIR SIGNALS

P4A

P4B

FOLDOUT FRAME

MOVING CHAIR SIGNALS



FOLDOUT FRAME 2

TECHNOLOGY INCORPORATED LIFE SCIENCES DIVISION HOUSTON, TEXAS 77058		
DRAWN BY M.H. UTLEY	DATE 11-23-84	TITLE WIRE LIST SLED CABLE, P4A & P4B LINEAR ACCELERATOR
DESIGN ENG		
PROJ. ENG		DWG NO TH8115-1E11
		SHEET 1 OF 1